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With 127 *Illustrations on Wood, drawn by the Author.*

LONDON:

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AND 290, BROADWAY, NEW YORK, U.S.

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1857.

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PREFACE.

The want of some especial Treatise on Cryptogamic Plants has long been felt by British botanists. The last edition of the English translation of Sprengel's *Introduction to the Study of Cryptogamic Plants* appeared in 1819; and whatever the merits of that work may be, it is wholly inadequate to supply the requisite information now. Dr. Burnett's *Outlines of Botany* contained some valuable notices respecting Cryptogams; and more recently, *The Vegetable Kingdom* of Dr. Lindley, especially the second edition of that admirable work, has brought together a mass of information, which is a most important acquisition to the student who has not access to the multitudinous works in which more modern discoveries are registered. Nor must I pass without notice *The Micrographic Dictionary* of Dr. Griffith and Mr. Henfrey, remarkable alike for the copiousness of the matter and the beauty of many of the illustrations. These, however, are not special treatises, nor calculated to supply completely the necessities of the student.

Nor, indeed, can I point out any treatise in a foreign language, a translation of which would have come up completely to the requisite standard. Bischoff's *Kryptogamische Gewächse* is admirable as far as it goes, but the design so ably begun was never completed; Eisengrein's *Einleitung* is without illustrations, and extends only to algæ and lichens; and Payer's *Botanique Cryptogamique,* notwithstanding the beauty and correctness of its very numerous engravings, is too slight in many parts to supply all that may reasonably be required, nor would it be possible for any English publisher, without the use of the original steel blocks, to reproduce it with any chance of remuneration.

It is not, indeed, supposed that the present work is without glaring faults, of which no one can be more sensible than the Author. Whatever faults, however, it may contain, they are not in general ascribable to carelessness. An incredible amount of labour has been bestowed upon its preparation, in the examination of herbaria, the consultation of authorities, and the verification of facts. Nor has he rested on his own judgment, but has profited by the counsel of friends, who have in more than one instance contributed valuable notes on subjects in which they are the highest authorities. Sir W. J. Hooker not only opened his rich Herbarium and Library, but gave much oral information on Ferns, Mosses, and Jungermanniæ; Dr. Hooker supplied some admirable notes on the geographical distribution of Ferns, besides giving much advice on a variety of subjects during the progress of the work; and Mr. Churchill Babington has contributed far the greater part of the information on the distribution of Lichens. The Author's most grateful thanks are due to these and other Botanists who have so readily acceded to his wishes, or have taken interest in his labours.

It remains only to state that the work is not intended nor calculated for persons who have not already some general knowledge of Botany. At the same time it is believed, unless the Author has entirely failed in his attempt, that there is no part which is not intelligible to any one who has made himself master of Dr. Lindley's or Dr. Balfour's Introductions to the Study of Botany.

King's Cliffe,
February 16th, 1857.

ERRATA.

Page 4, for *Cycads* read *Zamiæ*.
8, for *Hastig* read *Hartig*.
10, for *Browne* read *Broome*.
27, for *paradoxan* read *paradoxum*.
32, for *Birch* read *Beech*.
64, for *sorices* read *scolices*.
81, for *alliances* read *divisions*.
107, for *Nityphyllum* read *Nitophyllum*.
140, for *propagation* read *fructification*.
141, for *microscopium* read *microscopicum*.
142, for *albuminous* read *aluminous*.
145, for *forming* read *form*.
244, for *velutinus* read *velutipes*.
255, line 7, for *immense* read *large*.
290, for *oronata* read *coronata*.
316, for *graminum* read *graminis*.
355, for *Næmetelia* read *Næmatelia*.
368, substitute *A* for *P*, in lines 2, 4, and 15.
379, for *nearly* read *only*.
398, for *this* read *their*.
420, line 14, strike out *lampblack*.
461, for *Gœppert* read *Berendt*.

ADDENDA.

Page 77. Meneghini has figured annular vessels in *Sargassum linifolium* See Alghe Italiane, &c., Tav. 1.

Page 104. For directions for mounting microscopic specimens, see p. 420.

Page 282. The terms applied by Tulasne to the secondary or male fruit of *Sphæriæ* and Lichens, require explanation to those who are not in possession of his Memoirs When the fruit is conceived to be merely secondary, the perithecia are termed pycnidia, and their fruit stylospores; where it is supposed to be of sexual importance, the perithecia are styled spermatogonia, and their deciduous granules spermatia. Stylospores and spermatia may, however, be produced on threads not inclosed in perithecia. The term conidia is applied to such secondary granules as are neither stylospores nor spermatia.

Page 547. Hofmeister has lately given an account of the germination of the spores of *Botrychium Lunaria* in Bonplandia.

AN INTRODUCTION

TO

CRYPTOGAMIC BOTANY.

PRELIMINARY OBSERVATIONS.

1. A glance at the vegetable world, accompanied by nothing more than average powers of tact and observation, at once recognises the fact, that the members of which it is composed belong to several different divisions, more or less precisely shadowed out, and presenting distinctions readily apprehended by the practised eye, though perhaps at the same time incapable, if at all, of strict definition, without much study and reflection. The palms, grasses, and lilies, for instance, will be distinguished long before the peculiarities of their flowers, much less the intimate structure of their seeds, are so much as conjectured; and various groups in the other grand coordinate, as Umbellifers, Leguminosa, and Labiates, will, with equal certainty, be separated from the general mass, though meanwhile individual groups of the two grand classes of flowering plants will occasionally be confounded or misplaced, and far more members of subordinate divisions; and this not so much from want of correct observation, for I am not at present assuming any accurate examination of their component parts, as from the prevalent habit of confounding analogy with affinity. Thus, in popular language, species of *Lamium* and *Urtica* will pass under the same generic name, and *Nymphœa* will be supposed to have something to do

with *Lilium.** Attentive study will soon prove the two grand divisions above-named of Exogens and Endogens to be founded in nature, as far as any divisions can be shown to be so, by their mode of germination, the law of increase in their stems, and the venation of their leaves; and so in the minor groups, though there will be many a preconception to overthrow, still structure will as before confirm the indications of outward form, except, as said above, where such indications are mere matters of external resemblance, apart from every essential character.

2. The eye, however, will have already distinguished a third grand class,† more distinctly indicated perhaps even than the other two, though composed of parts still more widely differing from each other. It will have seen the rocks and trees covered with pigmy forms of vegetation, often displaying nothing like a leaf, or the peculiar green tint of the vegetable world; or if something approaching to a stem and leafy appendages be present, so cramped, attenuated and filmy, at once so easily dried up by heat, and capable of being restored by moisture, as to present something at once distinguishable from ordinary vegetation.

The waters, whether fresh or salt, meanwhile teem with other vegetable organisms, distinguishable at once from the mere aquatic Phænogams amongst which they grow, and

* After a patient examination of germinating plants, and an attentive consideration of the whole question, I cannot but subscribe to the view which considers *Nymphæa* as a true Exogen, notwithstanding some anomalies of structure in the common stem, and the peculiarities of the seed. Nor, again, can I subscribe to that view which would place *Nelumbium* and *Nymphæa* in different divisions, though, if that were correct, no better example could be adduced in illustration of the text.

† I cannot consider Dictyogens (much less Rhizogens and Gymnogens) as a class of the same importance with Endogens and Exogens. They are so clearly Endogenous, notwithstanding the peculiarities of the venation or much more of the structure of the stem, which may be easily studied by English botanists in *Tamus*, that, unless every anomaly is to be considered as overthrowing a natural division, we must either be content to leave them in company with their allies, or give up the attempt of natural arrangement altogether.

sometimes forming forests of vegetation as dense and almost as impervious as the jungles of the tropics. If the observer now turn to the soil itself, or to the fallen leaves and decayed twigs which are destined to increase its mass, a multitude of new beings meet his eye; fleshy gelatinous bodies of various sizes and forms, without a trace of anything approaching to a frond, mixed with mere threads and filaments; or carbonaceous structures, none of which can for a moment be referred to the other two grand classes of vegetables; and then when he has learnt to recognise some common attributes in these multitudinous forms, which lead him to comprehend them under one great division, he is cognisant of the fact, that there are other objects, often of considerable size, and sometimes acquiring the stature and in some measure the aspect of palms, covering frequently immense tracts of land to the exclusion of most other objects of vegetation, which, though forming a distinct group amongst themselves, are still referable to the other mass of organisms, at first apparently so heterogeneous, by certain peculiarities of vegetation, but more especially by the absence of those organs which are essential to the production of perfect seeds. He will indeed be liable at first,

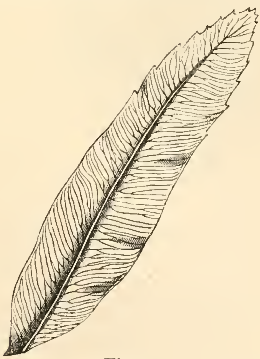

Fig. 1.

A single leaflet of *Stangeria paradoxa*, a Cycad lately discovered at Port Natal, to show the peculiar venation, so closely resembling that of many ferns, from a specimen communicated by Dr. Hooker.

as in the former instance, to make certain mistakes; he will ascribe, on a superficial view, those peculiar dwarf and tufted forms of flowering plants which occur at high altitudes in so many genera, classes, and orders, to the mosses under which name they are popularly known; he will not be able to distinguish or separate the Cycads from similar but not closely related forms, and even in a more instructed period, he will marvel at the resemblance offered by the fronds *Stangeria paradoxa** (Fig. 1), to certain ferns; he will confound, perhaps, some of the larger club-mosses with Conifers; he will be liable, on an inspection of the leaves only, to suppose that such plants as the Brazilian *Cupania filicifolia* (Fig. 2) are ferns, so close is the resemblance which its chaffy hairs give to

Fig. 2.

Part of a leaf of *Cupania filicifolia*, from the Kew Gardens.

the bipinnate leaves; and if his curiosity lead him so far as to note the vegetation which clothes the rocks in tropical rapids, he will be likely to fancy the whole group of Podos-

* In ordinary Cycads, as *Encephalartos horridus* and *Encephalartos pungens*, the veins all spring from the base and are nearly parallel, following the configuration of the leaflet.

temads (Fig. 3), as Algæ or Liverworts (Fig. 4);* and again,

Fig. 3.
a Apinagia pusilla, Tulasne.
b Mniopsis Hookeriana, Tul.
c Involucre of the same.
From Tulasne's Monographia Podostemacearum, Tab. 7, ii., and Tab. 8, v.

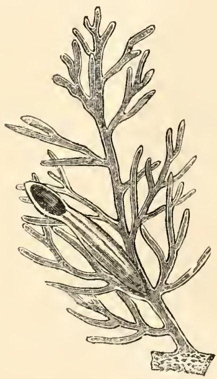

Fig. 4.
Sarcomitrium criocaulum, Mitten. From Hook. Musc. Ex., Tab. 72.

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* Modern observers have not always been free from this danger. Witness the illustration by Corda as a Liverwort in Sturm's Deutschland's Flora, Tab. xxxiii., Nos. 26, 27, of *Blandovia striata*, Cda. *Dicræa Wallichii*, Tul. was described by Taylor under the name of *Polypleurum orientale*, Tayl. MSS. in Trans. Royal Irish Academy, 1836. I have not access to the work, but I believe that Taylor made the same mistake as Corda. The genus is not recorded in Lindley's Vegetable Kingdom.

if his steps be turned to tropical forests, or to certain localities verging on the extremities of the temperate zones, he will find fungi in *Rafflesia*, and much more in the whole tribe of *Balanophoræ*. In every case, however, alike, he will be deceived by mere analogies, and the deception, with very rare exceptions, will tend towards the confusion of the lower Phænogams with the great class in question. It is to this class, long known under the name of Cryptogams, that our attention is to be directed in the present treatise.

3. The different parts of nature are so intimately bound together, and such unexpected resemblances occur every now and then, as if for the very purpose of arresting man for a moment in his investigations, and prevent him from supposing arrogantly that he can "find out the Almighty to perfection;" that it is impossible to give exact definitions like those which occur in pure science, which, without a single exception, shall separate with strict accuracy any one division, great or small, from another. The difficulty is just as great when in extensive and truly natural genera it is desired to separate one species from another,* as when the objects of separation and

* Botanists are not in general aware to what an extent this fact is exhibited in the vegetable kingdom, because for the most part they have only very imperfect materials, and therefore suppose that the distinctions between species are far more definite than they really are. In a large herbarium like that of Sir W. J. Hooker, in which specimens exist from every part of the world where a species may chance to grow, the truth of this remark will at once be apparent; and the veriest hair-splitter will pause before he inflicts on science a multitude of names which can lead to no useful result, but, on the contrary, make botany a trackless wilderness. Dr. Hooker, who has perhaps had better opportunities of realising this fact than any other botanist, has informed me more than once, that he was himself utterly unaware of the full extent of this difficulty before he undertook the preparation of the Flora Indica with Dr. Thomson. Not a single large genus which passed through their hands but exhibited the same difficulty, and in many smaller genera—take for example *Tetratheca*, Sm., as lately illustrated in the Flora of Tasmania—the task of ascertaining what are really species is scarcely less perplexing. In treating of ferns, we shall have especial occasion to call attention to this point. The *Carices* perhaps, as Dr. Hooker remarks, present the most definite characters, but even amongst these, the limits of species are not always very easily ascertained.

definition are the main or subordinate divisions of any one great class, or even, taking nature as a whole, when the question regards the highest divisions into which her productions are evidently distributed. In all these cases, definitions can only be assigned with that degree of limitation which is admissible where the exception may reasonably be held to prove the rule; or in other words, we must be content with pointing out some grand and leading marks of distinction, aware all the time that cases will occur in which these generally decisive tests will fail, so that it will be necessary to recur to other characters to prove the real systematic position of such organisms.

4. The first grand distinction of Cryptogamic plants is that, in contradistinction to Exogens and Endogens, they consist of cells only, insomuch that these higher orders have been denominated vascular plants, while Cryptogams are called cellular. Now, though the distinction holds good of a very large number of Cryptogams, yet two undoubted divisions, at least, the Ferns and Club-mosses, exhibit decided vascular bundles, nor, even were these excluded from Cryptogams, by assigning to them a distinct class, would our definition be more safe; for even supposing nothing like vascular bundles should occur elsewhere, or though it should be denied that true vascular tissue occurs in ferns, we shall still have true spiral cells amongst mosses, as in the leaves of *Sphagnum* and the elaters of *Hepaticæ;* and even should the true nature of the elaters in *Trichia* be denied, a point which there will be occasion to consider hereafter, we shall have as true vascular tissue in *Batarrea* (Fig. 5) as in any Endogen or Exogen.

We cannot, therefore, say that the absence of vascular tissue is the universal character of Cryptogams, nor, on the other hand, can an organism which does not contain such tissue be pronounced at once a Cryptogam. Podostemads may be found in certain states void of any appearance of vessels, and so may some other aquatics, but in some particular stage of growth spiral tissue will be found; and it must be recollected, in taking a view of such matters, that in all plants the early embryonic state consists of cellular tissue only, and

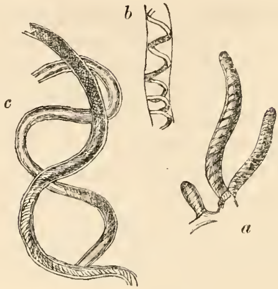

Fig. 5.

a Threads from peridium of *Batarrea phalloides*, P. magnified.
b A portion more highly magnified.
c Threads from capillitum of *Podaxon carcinomalis*.*

that vascular tissue is but seldom found in the young plant before germination.†

5. A second character, distinctive of Cryptogams, consists in the fact that growth takes place in these plants from the tips of the threads of which they are composed and of their ramifications; or in other words, that the development is superficial. This, however, must be taken with much latitude, for when we come to particulars, the exceptions are very numerous. The rule, of course, applies to their vegetative

* The threads of *P. carcinomalis* are rather allied to woody than to vascular tissue. They, in fact, resemble closely the elongated cells in the dark portion of the concentric rings of White Spruce Wood from the Arctic Regions, as observed lately by Dr. Hooker. A similar structure exists, in what I take to be Scotch Fir, in a piece of drift wood, picked up at Lake Laura, on the western side of Wellington Channel, and kindly communicated to me by Capt. Inglefield. It is now a well-ascertained fact that a spiral structure exists in some varieties of cellular tissues, and perhaps in all. Crüger's papers in the Botanische Zeitung, 1854, and Agardh[a] on the spiral structure in the cells of Algæ, may be consulted on this point. Hastig figures this spiral pleurenchyme under *Pinus pumilio*.

† A ready example to the contrary may be found in the fruit of the Horse Chesnut.

[a] De cellulâ vegetabili fibrillis tenuissimis contextâ. Lundæ 1852.

part, and not to their fruit; but even then the law is far from general. In such, *Diatomaceæ* for instance, as *Isthmia*, and *Amphitetras*, (Fig. 7), the development of the threads, though centrifugal, is by no means external; in ferns, the growth of the stems is clearly endogenous rather than acrogenous, and the same may be said of several of the more robust *Algæ*, which seem. at first sight, to have an exogenous mode of growth (Fig. 14), while those which increase by the repeated division of the cells into four, increase towards the centre quite as much as towards the circumference. Indeed, if Hartig* and Trécul's† views of the development of Exogens be adopted, the mode of increase of the woody tissue resembles perfectly that of many Confervæ, the new growth being supplied by the repeated division of the terminal cells of the component threads of both the alburnum and liber. It is not indeed pretended that other modes of division do not exist, but the more normal mode of growth really shows the tissue to be more closely identical with Confervæ than even Agardh imagined. It is very doubtful, however, whether this learned algologist ever intended more than the indication of a close analogy or, to advance a step further, a distinct representation.

6. A third distinction, and one of high importance is, that though Cryptogams have, at least many of them, decided differences of sex, so that they cannot correctly be termed Agamous, there are no true pistils, neither are there anthers, supposing the proper function of anthers to be the production of pollen. The bodies which in ferns, mosses, and other of the higher Cryptogams, perform the function of pollen, and which are produced in a peculiar cellular tissue much after the fashion of pollen grains, approach much more closely in form and general appearance to spermatozoa; and though there be sometimes distinct organs for their reception, impregnation takes place immediately by simple contact, and not by means of a thread germinating from a pollen grain. Even amongst

* Hartig Ueber die Entwickelung des Jahresringes der Holzpflanzen. Bot. Zeit. 1853, p. 553.

† Trécul in Ann. d. Sc. Nat. Sér. iii., vol. 17, p. 250; vol. 19, p. 157, 258.

some of the lower Cryptogams the impregnating bodies preserve an animal type, and it is to be observed that direct proof of the function of these bodies has been elicited amongst Algæ, in the first instance by Thuret,* and afterwards by Pringsheim† and his followers. Where the flagelliform appendages characteristic of spermatozoids disappear, as in Lichens and Fungi, there is still molecular motion ; and if *Leptomitus* (or as it is sometimes called *Saprolegnia*, *Achlya*, &c.), as I believe to be the case, is a true Fungal, even amongst these we shall have the animalcular form.

7. A fourth distinction of equal importance with the last is the absence, in general, of everything, so far as the spores are concerned, in the shape of an embryo.‡ In every case the spores consist of one or more cells composed of two or more membranes inclosing a grumous mass, or occasionally

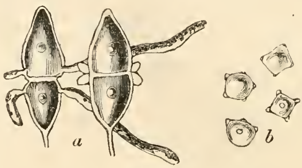

Fig 6.

a Spores of *Coleosporium* pingue, Lév. magnified, shewing several germinating points arranged symmetrically.

b Ditto of *Podisoma fuscum*, magnified as observed by myself and Mr. Browne.§

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* Thuret, Recherches sur la fécondation des Fucacées, suivies d'observations sur les Anthéridies des Algues. Ann. d. Sc. Nat., Sér. iv., vol. 2, p. 273.

† Pringsheim in Monatsbericht der Kön. Preuss. Ak. zu Berlin, March, 1855, p. 133.

‡ If, however, by an embryo is meant a young plant ready formed, and only waiting for the evolution of its parts, we cannot deny that the spores of many of the lower Algæ and of such fungi as *Antennaria Robinsonii*, Mont., contain an embryo. In the latter case, however, the mode of reproduction is not apparently normal.

§ Gard. Chron., 1849, p. 261. Ann of Nat. Hist., Ser. 2, vol iii, p. 531. The woodcut of both these fungi was prepared before the appearance of Tulasne's second memoir on the Uredinées.

inclosed in an integument which is itself composed of cells.* Germination takes place by the extension of one or both of the constituent membranes, in consequence of which they are essentially acotyledonous, and in general the point of growth is indifferent,† though sometimes, as in certain species of *Uredo*, *Puccinia*, &c. (Fig. 6), indicated by spots or apertures in the outer integument, through which the germinating threads protrude exactly after the fashion of pollen tubes. The spores, indeed, of such Fungi bear the closest similarity in structure to many pollen grains, though their functions are very different.

These germinating tubes either reproduce the plant directly, or give rise to a membranous expansion of a peculiar form, or cushion-like swelling *(prothallus)*, which, in due time, bears the frond, fruit, or stem proper to the species.‡ In the higher Cryptogams, a single spore alone gives rise to a plant; but even amongst the foliaceous species, as in certain mosses,§ a number

* In *Selaginella* a portion only is cellular in the form of a little disc. The formation and thickening of this disc is all the germination which takes place in the spores, which are, however, of very different value from those of many other Cryptogams, as will be seen in the sequel.

† There seems at first sight to be something like this in the fleshy seeds of *Crinum*, and some other allied genera, as the radicle appears at the point where the seed touches the soil; but these bodies do not consist of a mere mass of homogeneous cells, but contain, as will be seen on close examination, a fact pointed out by Robert Brown in his Prodromus, a distinct embryo, as perfectly formed as in other Amaryllids.

‡ It is quite clear that nothing ought to be reckoned as a cotyledon which is not present in the perfect embryo. The cotyledons may be soldered togetheras in *Clintonia*, much reduced as in endogens, or obsolete as in *Cuscuta*, but still their presence may be regarded as almost universal in the higher plants. It is, however, clear that they cannot exist in Cryptogams where there is no embryo, and therefore perhaps one of the most unobjectionable names which has been applied to them is that of Acotyledons. The name of Pseudocotyledons or Cotyledonoids, which has been given to the germinating threads, is founded on a false notion as to the nature of their reproductive bodies, and should be rejected as calculated to mislead. Some of the higher Cryptogams, however, have an embryo, and in *Selaginella* the first two leaves are opposite, and have much the appearance of Cotyledons.

§ Kützing in Linnæa, vol. 8, tab. 7.

of spores, if recorded observations are to be trusted, concur in the formation of a single plant. But whether this be so or not, it is quite certain, without having recourse to such theoretic notions as would make an Agaric to consist of a mere closely compacted mass of mucedinous filaments, bearing fruit at their apices, that many fungi arise from the confluence of mycelium germinating from many spores. Ehrenberg* has long since shown in *Erysiphe* and *Clavaria*, that numerous spores concur in the production of an individual plant; and no one can be a diligent observer of fungi under all their phases, without being convinced of the fact. How far the concurrence of a number of spores may be absolutely necessary is uncertain.† The union by means of anastomosis is as intimate as if all the threads of the mycelium were derived from a single spore, and is not to be regarded in the same light as that kind of union which takes place in grafting amongst Phænogams; for though it is possible that in the process of budding and grafting, the divided cells of the graft or scion may, in certain rare cases, coalesce—so as to form a single cell partaking of the nature of both (a matter, however, which can be only conjectural),—as, for example, in the variety of *Cytisus* which bears the proper

* Ehrenberg de Mycetogenesi.

† Individuality amongst fungi is, after all, very different from what it is amongst Phænogams. If two trees become united by the inosculation of their roots or branches, no one would consider them as a single individual; whereas many fungi which pass for individuals originally consisted of numerous distinct plants. Take, for instance, one of those *Thelephoræ* which creep over the surface of branches, and arise from the orifices of *Sphæriæ* with which the bark is studded. There may at first be a hundred distinct patches, each in itself showing all the characters of the species, and in perfect fruit; as these, however, spread, they fall in with other individuals, which become perfectly confluent, and the common patch differs only from those of which it is composed in its larger size. The hymenium is perfectly continuous, and does not exhibit a trace of the members of which it is constituted. No one would then hesitate to consider it an individual. Patches of moss might become confluent in the same way, but the commonest observer would at once see that they were mere masses consisting of a thousand or more individual plants, interlaced indeed, and almost inextricable, but still distinct.

flowers of two distinct species on the same branch intermixed with others partaking of the peculiarities of either species, — the case in general is one of mere apposition, the stock simply supplying the nutriment which is necessary for the development of the graft; and in those cases where the truncated base of one tree is supported by the inosculating roots of another, the new wood formed is due to the old stock, the nutriment from which it is developed being derived from the extraneous fountain. Unless, indeed, the visions of the descent of wood in the shape of fibres coming down from the buds which so long possessed the imaginations of first-rate physiologists, in the face of facts which were perfectly irreconcilable with their truth, are to be regarded as true: visions which are now happily exploded by the brilliant observations of Trécul.*

8. We have now then arrived at some general notion of the large mass of plants known under the name of Cryptogams, and are prepared to give such a definition as the case admits. But before doing so, it may be well to say a few words about the name which is so generally assigned to them. If it conveys no incorrect notion, it will of course be far better to retain it, than to adopt some other of less familiar sound. It has already been observed that the denomination Acotyledons is almost unobjectionable; and perhaps if, the cognate terms of Monocotyledons and Dicotyledons were universally received, it might be as well to take it at once; but these names have given place in a great measure to the terms Endogenous and Exogenous, without however the advantage of increased precision, and as the word Phænogams is very generally used as a collective term for flowering plants, that of Cryptogams has a decided claim in preference to others. The term Asexual plants is opposed to the fact, that sexual organs or their representatives do exist in every division; that of Cellular plants does not accord with the whole order of ferns, without mentioning other ex-

* L.l., cit. supra, p. 9.

ceptions; the term *Homorgana* is synonymous with *Cellulares;* the term *Nemeæ,** applied by Fries, alludes to the fact that the spores germinate by means of a protruded thread without any indications of Cotyledons, but there are many of the lower Algæ in which the spores can scarcely be said to germinate at all, and certainly protrude no thread, and the spores of the higher Cryptogams are altogether anomalous, so that the term is not more strictly definite than others; *Sporophoræ* and *Sporideæ* indicate the nature of their organs of reproduction, which, as being destitute of an embryo (a circumstance not without exception) are no true seeds; *Ananthæ* is the same with Flowerless, a term often applied to Cryptogams, and only applicable when the word flower is made to include stamens and pistils as well as floral envelopes, for these latter exist certainly in mosses and liverworts; the word Acrogens indicates the apical mode of growth, which is not however an universal character; and finally, that of *Favi*, except it be

* Fries, in his Systema Orbis Vegetabilis, states that four general names, may be given according as the different phases of vegetable life are taken into consideration. Thus, according to germination, they are *Nemea*, germinating, that is, by a thread, and not by a radicle composed of a cellular system with one or more cotyledons; according to vegetation they are *Cellularia*, as in the greater number of species there is no vascular tissue; according to the mode of flowering they are *Cryptogama*; and according to their fruit, *Sporidea*, destitute of an embryo. Fries then gives his reasons for preferring the word *Nemea* to *Acotyledonea:* 1. Negative determinations are always of an inferior rank, and must give way to positive when accurately determined. 2. The necessity of the word for the formation of the terms *Homonemeæ* and *Heteronemeæ*, descriptive of the two great divisions of cryptogamic plants. 3. Analogy; as, for instance, *Evascularia* is not to be preferred to *Cellularia*. 4. Because of its greater precision, for true *Acotyledonous* plants exist amongst Phænogams, as *Cuscuta*. The progress of science, however, will always indicate exceptions to any term which may be invented. New terms, however excellent, always produce a certain degree of opposition at first, and are at length unwillingly received. If the present work were published under the title of an Introduction to Nemeous Botany, half the world would not known what was meant, and the other half would set the writer down as a pedant of the first water, *inter omnes res maxime vitandus*.

synonymous with *Cellulares*, is of a doubtful meaning. In adopting the word Cryptogams, which was originally applied rather by tact than knowledge, but is not by the progress of science exempt from the reproach of being merely superficial, I feel rejoiced not to transgress the maxim of Fries, which I believe to be deeply founded:—*Characteres essentiales plerumque maxime absconditi et acute inquirendi, cum accidentales simul maxime superficiales.*

CRYPTOGAMS.—*L. Brong.*

ACOTYLEDONES, *Juss. De Cand. Meisn.*—CELLULARES, *De Cand. Lindl.* (1830.) *Meisn.*—HOMORGANA *Schultz.*—ESEXUALES, *Lindl.* (1833, 1845.) —SPOROPHORÆ, *Horaninow.*—ANANTHÆ *Martius* (excluding Fungi). —ACROGENS *Lindl.* (1839.)—FAVI, *Trautvetter*—SPORIDEA, *Fr.*

CELLULAR, or more rarely cellulari-vascular, flowerless plants, often destitute of stem and foliage, propagated by simple or compound microscopic spores, germinating by means of one or more simple threads, and rarely containing any embryo, sometimes producing a prothallus, which gives rise to secondary spores or young embryonic plants, increasing mostly by additions to the external surface, exhibiting sexual distinctions, diclinous or monoclinous, but never producing true stamens or pistil, and consequently possessing no true pollen, but on the contrary, impregnated by spermatozoids, either provided with or destitute of slender flagelliform motile appendages.

These characters may be expressed nearly in the terms which have been applied to the whole class by authors, each of which contains much truth, modified by more or less rare exceptions.

1. *Cellularia. Homorgana. Favi.*
2. *Acrogena.*
3. *Anantha. Cryptogama.*
4. *Sporifera. Sporidea. Nemea.* (Exembryonata.)

9. It may be well before we proceed further, to test the practical value of the definition in one or two anomalous instances. *a.* Suppose, for instance, the student after a few hours rain, goes out into the open air, and sees the gravel and short grass strewed with gelatinous puckered olive-coloured masses, of which he perceived no trace a few hours before : his curiosity is excited and he is anxious to ascertain the nature of the production. Externally it presents no marked differences, and within it seems to consist of a uniform jelly, without anything to make him suppose that it can be a mass of eggs. He examines it under the microscope, and he finds that it consists of necklace-like chains of pellucid granules immersed in jelly of no definite structure. Some of these are larger then the others. He finds after a time that they change colour and increase considerably in size, though still retaining a regular outline ; presently, the matter contained in their cavity becomes organised, and a new necklace of spores is contained within it ; in fact, he has a young repetition of the perfect plant, requiring only extension of parts to assume completely its size and aspect. This answers to the first part of the definition, but the plant does not germinate as described ; he can discover no sexual indications, though germination does not take place by the protrusion of a filament, and the protoplasm of the cell at once gives rise to a new plant. He believes it to belong to the vegetable kingdom, and he feels that he has hit upon one of those exceptional cases which defy mathematical accuracy. But still he has no doubt about the matter. The plant is *nostoc commune*, a widely-distributed Alga, bordering very close on the gelatinous Lichens. *b.* He is again attracted by some little pearl-like bodies upon a decayed stick ; he carries it home with a view to examination, and the bodies have lost their soft consistence, and present little skinny bags filled with elastic fibres and dust. He finds these elastic fibres to be most beautifully-constructed spiral vessels, with several helices curiously and regularly twisted within them. He wonders to find such vascular cells in a plant which presents no indications of leaves or stem. On closer examination, he finds that the

dustlike bodies are regular globose cells; a few of these are placed on damp glass, they germinate readily, protruding a single thread. He perceives then, notwithstanding the spiral

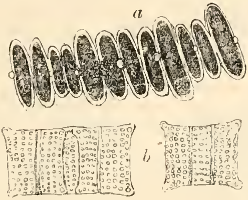

Fig. 7.

a. Sphærozosma elegans, Cord. Eng. Bot. t. 2939.
b. Amphitetras antediluviana, Ehrb. Ralfs in Ann. of Nat. Hist., vol. xi., p. 276, tab. 8, fig. 5.

cells, that he has before him at least one characteristic feature of Cryptogamic plants, and he is satisfied that he has again fallen on an exceptional case. He has got a Fungus of the Genus *Trichia*. *c.* A green slimy matter in a little pool upon the neighbouring heath attracts his notice. This also he submits to his microscope, and sees that it is a production of astonishing beauty, consisting of many couples of curiously pinnatifid joints. (Fig. 7, *a.*) On examination, he is sure that increase does not take place at the tips, but from the division of the component joints. The plant is not then acrogenous, but it is so completely cellular, that without knowing exactly what the fruit is, he concludes at once that he has got a Cryptogam, and a further knowledge of closely allied forms will convince him that he has been correct in his apprehension. He has found some difficulty in every case, but he has found it still more impossible to suppose that he had anything to do with Phænogams. *d.* Soon however he is still more perplexed. The leaves which lie in the low waterspout of his conservatory are covered with a dark red coating. This also is submitted to the microscope, and he has wonders enough before him. Here are globes filled with uniform matter, the endochrome or protoplasm so common in vegetable cells; others, in which the protoplasm has parted into a definite number of bodies, always multiples of four when he is able to count them, except when in a state of transition; these bodies at length separate, and to his astonishment he sees them of different sizes moving about with great rapidity by means of two long slender appendages. The motion at length ceases, and the bodies soon swell and repeat the same phases. (Figs. 8, 9.)

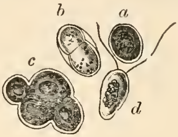

Fig. 8.

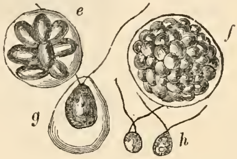

Fig. 9.

Fig. 8, *a*. *Protococcus pluvialis*, Flotow, immersed in water after having been perfectly dry, magnified.
b. Ditto, with the endochrome divided into two.
c. Ditto, divided into four, the central nucleus red, the border green.
d. Separate spore, with two flagelliform processes.

Fig. 9, *e*. Cell containing eight scarlet spores.
f. Ditto containing numerous green spores.
g. Ditto with a scarlet spore in its cavity, furnished with flagelliform processes.
h. Two spores, green below, scarlet above, all more or less magnified.

From Cohn Nachträge zur Naturgeschichte des Protococcus pluvialis, Flotow.

His difficulty now is to say whether he has an animal or vegetable before him. *e*. But a very few days previously he had found in the neighbouring water tub a mass of green threads,* of which he has ascertained the purely cellular structure, the acrogenous growth, and finally, the formation of spores from some of the joints; and these, when free, he has seen moving about by means of a little coronet of filaments, and then, like his red globules, subsiding into rest, and germinating by a single thread which soon acquired joints, and was a complete reproduction of the parent filament. He is then satisfied that his red globules also belong to the vegetable world, though exhibiting certain attributes usually supposed to belong

* *Ulothrix mucosa*, Thuret.

exclusively to animals. He concludes, therefore, that he must not expect the whole of the definition to answer, and is content if he can find one point at least which leaves him in no doubt.

10. All these cases were more or less exceptional, but he finds others which present far less difficulty, none perhaps which do not present some, and he soon perceives that there is a common band which binds the whole, however different the parts may be, and, as he gets to subordinate divisions his difficulties rapidly diminish. The number of points of agreement, that is, will increase, while those of difference decrease, though he will scarcely find one production which does not in some particular depart from the terms of any definition which can comprise the whole. Few students would, however, have worked this out for themselves. The confusion would have seemed so inextricable, that they might well have given up the matter in despair, and yet, if the caution be once well understood, that we are not to look for mathematical precision or for characters which can, without failure, include every form in groups manifestly bound by some common tie, there is no more difficulty than would be found in any definition of Phænogams taken from characters which are not universal. All Cryptogams are reproduced by spores, and all Phænogams by seed; in one (as a general rule) there is no embryo, in the other an embryo always exists; and yet, if germination by means of a protruded filament be the essence of a spore, there are many Cryptogams which will not come under the definition. Meanwhile, however, he will have found interest increase with the examination of the new world to which the microscope has introduced him, and he will not be long before he sees that the interest does not cease with the mere ascertainment of the structures before him, but that a vast field of physiological wonder is opened to his view.

11. And here the great importance of Cryptogamic Botany forces itself upon us. It has often, indeed, been objected, that so much credit is not to be obtained in the pursuit of this branch of botany as in the investigation of the more highly organised vegetables; and some of the first Cryptogamists of our day have felt this so strongly, that they have even been in

a great measure diverted from their original pursuits by such a notion. I am convinced, however, that it is altogether groundless; few names are more honoured than those of Hedwig, Persoon,* and Agardh, and it would be easy to point out, if it were not invidious, numerous names which hold a primal rank amongst botanists exclusively on account of investigation in Cryptogamic Botany; added to which, some of the more honoured Phænogamists owe quite as large a portion of their fame to their cryptogamic observations as to those in the higher classes of vegetables. Numerous, for example, as the services of Sir W. J. Hooker have been amongst Phænogams, and it is difficult to appreciate them at their full value, there can be no doubt that his reputation as a botanist will rest quite as much upon his *British Jungermanniæ* and *Musci Exotici*,† as any of his other very numerous publications, not to mention his direct services to science and commerce in his unparalleled exertions at Kew. That a great number of cryptogamic botanists should be held in little esteem, by reason of confined views and uninstructed minds, is no more surprising than that there should be hosts of phænogamic botanists whose names are scarcely known, except to those who have the misery of being forced to consult their works, which might, indeed, with incalculable advantage to science, be overlooked altogether; and amongst such must inevitably be reckoned numerous writers of the present century, who are daily adding bad or spurious species to the overwhelming mass of ill-defined matter already existing; who not only have no enlarged views of the science they profess, but are at the same time destitute of the will to investigate, for they are not without the gift of diligence, the main object being to make a fair show in the flesh by the multitude of species

* Persoon's fair title to a place amongst the *Principes* rests upon his Synopsis Fungorum, the first successful attempt after the rise of the Linnean nomenclature to arrange the species of Fungi in a systematic form. He was the first describer, indeed, of a multitude of species, but his fame does not rest on this part of his labours, and his latest work scarcely bears out the reputation derived from the Synopsis.

† Of all his works, this is perhaps the most beautiful. The figures have scarcely been surpassed in truth and elegance.

bearing their own agnomen. Indeed, with the meagre materials which too often fall to the share of such botanists, it is impossible but that, without enlarged views, they should fall into continual error. If for example a single specimen of each form should be selected from the noble series now at Kew, made with a view to the illustration of the Flora of Tasmania, consisting of several hundred individuals of particular species, it would be almost impossible, without much enlargement of mental vision in addition to great nicety of tact, to avoid making some twenty species of what to a person with all the materials before him are evidently one and the same,* and this is far more applicable to cryptogamic plants, where it is often quite impossible to frame a specific character from outward form sufficiently comprehensive, but where, on the contrary, characters drawn up from individual specimens, might seem to indicate good species. Take, for instance, almost any widely diffused species of fern, and it will be well if generic characters as well as specific are not at fault. But a more fitting place for the discussion of such variation will occur hereafter.

12. Having made these observations to meet the susceptibility of any who may be inclined to think that cryptogamic botanists are less honoured than is meet, or the prejudices of students who might, in consequence of such a thought, be deterred from a most interesting and important branch of study, I proceed to show the real objects which lie before the Cryptogamist; meanwhile premising, that he can scarcely hope to derive all the profit which is possible, unless he be tolerably well versed in the structure and physiology of the higher plants. At the same time, though his attention may be more especially directed to one particular branch of Cryptogams, if he wishes to work with any certainty, or to arrive at any permanent results, he should by no means neglect altogether other branches.

* I speak of this from personal knowledge, having been kindly allowed to select a complete set for an eminent Swedish botanist. It was at once manifest what inextricable confusion must arise if the Flora were attempted to be worked up from scanty materials. Not only would mere forms be erected into species, but each form would give rise to nearly as many species, in some instances, as there were individual specimens.

13. I shall not dwell upon the extreme and manifold interest of the several objects which come within the view of the Cryptogamist. If variety and delicacy of structure, beauty of form and colour, and the nicest transitions from group to group, from genus to genus, besides a host of curious questions of physiology and adaptation of means to particular ends, are worthy to engage attention, Cryptogams most surely will not be amongst the most unprofitable objects of study. There will be scope, too, for the acutest powers of thought and observation, unless he is content merely to skim the surface of things. Even independently of the necessity of using optical instruments, a point often much exaggerated, for if the minuter points of physiology in Phænogams are deeply studied, no less an amplifying power is necessary, and perhaps even greater tact and skill in manipulation, the difficulties which arise from the wide limits within which not merely species but accredited genera are capable of varying, are sufficient to exercise the highest mental qualifications. It does not follow, however, that the end obtained should be at all proportional to the necessary labour. The objects which the accomplished Cryptogamist has in view, are not comprised within the mere determination of species or the admiration of the exquisite forms and combination which meet him at every turn. If he aims at nothing higher than the first, he may indeed be useful in his generation, provided he be cautious enough, and possessed of sufficient self-denial to prevent his striving to glorify himself, rather than to clear the road for investigators of higher pretensions. If beauty of form and singularity of structure be alone his object, his time may be passed agreeably enough, but in most cases, like ten thousand microscopists of the present day, he will be but a mere trifler, without any better aim than innocent amusement; or if he be a dabbler in science, with some wish to attain a reputation which he has not the patience to seek after by a continued course of study and mental discipline, he will be deriving general inferences from isolated half-understood facts to the detriment and confusion of real science. Perhaps, of all literary dissipation, the desultory

observations of the mere microscopist are the most delusive. And even where the objects are higher, it is well that every one whose attention is much directed to this greatly abused instrument, should remember that if he wishes to penetrate the secrets of nature he must look beyond his microscope, a fact of which some microscopists of considerable reputation do not seem at all aware.* The paramount importance of the subject is to be seen in far different matters.

14. The first great point is that the physiologist is able, in the simpler Cryptogams, to study the several organs of which the higher vegetables are composed, isolated and altogether removed from other structures which may impede the view, or by their rupture cause confusion. If, for instance, it is desired to ascertain the mode of growth in cells, he will be able to appeal to the simpler Algæ, whether grumous or filamentous. In the one he will be able to trace step by step the division of the primitive mother cell, with nothing to prevent his view in consequence of the great transparency of the walls; or if he take one of the simple or branched *Confervæ*, he will be able to assist at the origination not merely of two new cells from the subdivision of one, but the formation of a new cell by pullulation from the walls. Meanwhile he can ascertain exactly what changes the endochrome is undergoing, he can watch the part which the cytoblast bears in the process, and can sometimes trace its partition. He can investigate in many cases, as in *Zygnema* and its allies, or much more in *Chara* and *Nitella*, the currents which traverse the length and breadth of the cells; he can trace thickening of the walls by the deposit of new coats, and in some cases the shelling off of those which are effœte and have performed their office. He can observe, moreover, the wonderful union of separate filaments, the formation of a vital spore from the union of the contents of neighbouring cells, and many other points of interest, which throw more or less light on the

* I allude here especially (amongst many like instances) to the utter indifference with which Mr. Thwaites' great discovery of the conjugation of *Diatomaceæ* was received at the Oxford meeting of the British Association, by one whose whole reputation was built on the microscopic study of these and other analogous organisms.

processes which occupy the attention of the investigator of the vital processes of the higher vegetables. Amongst the lowest vegetables he will find many facts which will give him points of comparison with inmates of the animal kingdom; he will see apparent Infusoria existing as mere vegetable organs, and will find them performing functions under a form which he will in vain hunt for amongst the higher vegetables, and if his attention be turned to those Cryptogams which more closely resemble these in outward appearance, he will find a form of spermatozoid so closely resembling the impregnatory bodies of the higher animals, as to open his mind more strongly than ever to a conviction of the intimate bond by which all the members of the organised world are bound, though he may not subscribe to those theories which deny the existence of definite groups. There can be no question in these cases of the spermatozoids being developed in perfect freedom within the mother cells, and not mere appendages separated from their walls, and endowed with a vital action, similar to that of the cilia, so common to mucous surfaces, as many animal physiologists assert. Such investigations will come in aid then of those relative to the development of spermatozoa in animals, and similar advantages will be presented in many other instances,* and consequently the cryptogamic student will be able to form more exact notions as to vital action in the animal and vegetable kingdoms, than are usually held by those who confine their investigations to either division of the organised world. Again, though spiral vessels are comparatively rare in Cryptogams, opportunities of studying their development and nature are nowhere more available than amongst the *Hepaticæ*,† where they occur without the intervention or attachment of any other tissue, while in *Zygnema* the curious and multiplied spiral bands may with ease be traced from the first formation of the cells in which they are developed.

15. There is another point of immense importance, which the cryptogamic observer has in a peculiar degree the power of stu-

* Martino in Ann. d. Sc. Nat., sér. iii., vol. 5, p. 171, on the development of Spermatozoa in the Skate.

† See Henfrey Linn. Tr., vol. 21, p. 103.

dying successfully. Questions often arise as to the point whether cellular structure can originate without the presence of a previous mother cell. It is a question, for instance, whether cells are ever formed in Phænogams from mere organisable sap, as presumed by Mirbel in his paper on the Date Palm ;* or again, whether, in what is called organisable lymph in the animal world, cells can originate freely without pullulation from neighbouring tissue with which the lymph is in contact. In the blood, once more, are blood globules, or in unhealthy conditions pus globules, ever formed simply from the constituents of the blood itself, without the concurrence of previously formed organisms? Now in those fungi in which, as in *Sphæria* and *Peziza*, the reproductive bodies are generated by the endochrome of the fructifying cells, the Cryptogamist has the power of watching the development of the spores from the very moment when the endochrome commences to be organised, and he can with confidence assert that they are not the creatures of previously-existing cells, but the produce of the endochrome itself. He will be able to compare with this what takes place in the embryo sac of Phænogams, and will be better prepared to appreciate all the arguments which bear upon the Schleidenian Theory of the formation of the embryo. Both the formation of the albumen and of the embryo itself will then be studied with greater zest, and he will certainly, after watching the origin of spores within an ascus, be able to judge better of what takes place or does not take place within the pollen tube. It is true that many of the points I have

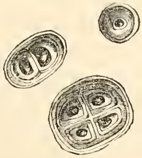

Fig. 10.

Glæocapsa rupestris, Kütz, magnified, from specimens communicated by M. Brébisson, from Falaise. The simple spore has first given rise to two new spores, and then to four.

* Ann. d. Sc. Nat. Sér. 2. vol. xi. p. 321.

mentioned may be examined profitably in Phænogams, but always with more difficulty, and seldom with such precision or with such satisfaction and conviction to the observer, and there is one point which must always be borne in mind, that the objects in question grow and are developed under his eyes, if he possesses proper powers of manipulation, which will scarcely ever be the case with Phænogams, if the parts be freed ever so neatly from the surrounding tissues.* Nay, the examination of the developement of cells in such genera as *Hæmatococcus* and *Glœocapsa* (Fig. 10) will help even the Zoologist, for nothing can be more close than the mode of development in these, and of the vitellus in the eggs of certain *Mollusca* (Figs. 11, 12).

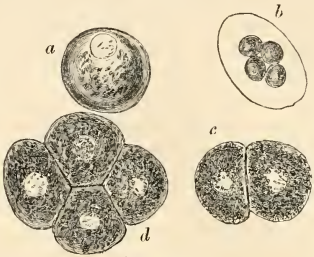

Fig. 11.

Eggs of *Acteon viridis* in different stages.

a. Egg, showing the vitellus still simple.
b. Egg, with four celled vitellus.
c. The vitellus divided into two.
d. Ditto into four.

From Vogt Recherches sur l'Embryogénie des Mollusques Gasteropodes, Ann. d. Sc. Nat., sér. iii. vol. 6, p. 1.

The bodies, indeed, which are so much alike, or in other words are homologous, identical, that is, in structure and genesis, though not in function, may not always be of equal

* Most eminent vegetable Physiologists have been more or less Cryptogamists. One of the earliest studies of Mr. R. Brown was Schmidel's Icones, a work which anticipates many modern observations, as the spiral structure of the threads in *Trichia*, and the motion of the Spermatozoids in *Jungermannia*, and one of the best memoirs on the development of the embryo in vegetables, is that of Tulasne.

value; but the student will learn as much, perhaps, from the observance of their differences, as if they were in every respect perfectly accordant.

16. There is another point which makes the study of cryptogamic botany peculiarly interesting, viz.:—because so large a portion of fossil vegetation is so intimately related to some of the nobler Cryptogams, and possibly exhibits far grander and more highly organised individuals than any which at the present æra occur in a living state. It is fortunate that these, in some cases, still retain their spores in such a perfect condition, as to admit of accurate appreciation. In some fossil fruits,* indeed, which have certain *primâ facie*

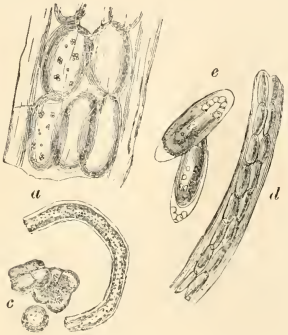

Fig. 12.

a. b. c. Eggs of *Aplysia depilans* from Vanbeneden Recherches sur le dévelopement des Aplysies, in Ann. d. Sc. Nat., sér. ii. vol. 15, p. 123.

a. Contained in thread, natural size.†

b. Thread and eggs magnified, showing the quadricellular vitellus.

c. Vitellus in different stages, highly magnified.

d. e. *Gloionema paradoxan*, Ag., being in fact the eggs of some Tipula.

d. Thread, with its rows of eggs magnified.

e. Eggs highly magnified. - See Berk. in Ann. of Nat. Hist., vol. 7, p. 449.

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* *Carpolithes Ovulum*, Brongn. and *Folliculites minutulus*, Bronn. Hook. fil. in proceedings of Geological Society, 1855, p. 562, 566.

† This is, I believe, *Ulva defracta*, Eng. Bot.

claims to admittance into the series of cryptogams, and would undoubtedly vindicate these claims, were it sure that the bodies contained in their cavity were spores, the membranous coats which line their cavity are still as flexible as they could have been in life, exhibiting every marking and peculiarity of structure with the greatest precision, and in some cases, presenting a double lamina capable of separation at the point of confluence, while each possesses its own cellular arrangement. It is amongst fossil plants, if anywhere, that we must look for indications of the highest perfection attainable by Cryptogams. Meanwhile, an accurate acquaintance with the habits of those species which still exist upon the earth, and of the temperature and climate in which they flourish, may possibly afford some key to the questions which so often occur to the geologist, respecting the climate which must have existed on the earth at the time of some given geological formation, to allow of the luxuriant development of these gigantic forms. Nor are these the only kind of Cryptogams which abound in certain strata; there are numerous others which are immediately and certainly comparable with existent species. Many forms occur which have no modern analogues, or are in such an altered state, as to allow of little more than conjecture as to their affinities; and even the ferns themselves, whose form is often so beautifully preserved, so very rarely produce fruit, as to lose much of the interest they would otherwise possess; but the siliceous cases of *Diatomaceæ* are preserved in such extreme perfection, as to be as satisfactorily comparable with existent species as the remains of mollusca, and, as in those, a host of species may as safely be pronounced identical.

17. Another excellent inducement to the study of Cryptogams is the fact that so many of the diseases, both of plants and animals, arise from their presence. The species which affect animals are probably few in number, and for the most part of common kinds, possessing great powers of ubiquity, and therefore able to establish themselves on what, from the very nature of things, cannot be their natural habitat. Though great attention has been paid to the study of such Cryptogams, as infest man, and other animals, they have seldom been

studied by competent persons, possessed of an accurate knowledge of species, much less of a power of appreciating the changes which may take place in the same species, according to varying outward circumstances. Those who have recorded their occurrence, or have given figures illustrative of their aspect and structure, accompanied by distinctive characters, have often been physicians better versed in anatomy and microscopy than in cryptogamic botany, and often unable to distinguish a mould from an Alga. The parasites of the vegetable world are much more numerous, and are clearly autonomous; and as some of them produce great ravages on those plants which most subserve the use of man, their study is of immense economical value, apart from other less utilitarian considerations. Till these parasites are accurately distinguished from each other, all attempts at remedy must be empirical; and thus, in the case of the diseases which affect the hop, no efficient remedy was even attempted till the nature of the two principal diseases with which the plant is affected, known under a multitude of names, was accurately ascertained.*

18. No student of these lower vegetables, then, need blush for his choice. His wisdom plainly is not to confine his views within a narrow prescribed limit, and above all, not to the mere study of species, though that alone is far more imperative than numbers of pseudo-physiologists will allow. Without it, the results of his observations can scarcely be conveyed with certainty to others, and their field will be greatly circumscribed. The study of species in itself is of great utility, if conducted on broad and sensible grounds. If he takes a wide view of things, he will be sure in the course of his investigation to throw much light even on points which, perhaps, in the first instance, he might least think of being able to illustrate.

19. Nor will a few words on this subject of species be completely out of place, though we have incidentally touched on it before. It is one which the cryptogamic student will meet with at every turn. It is a common opinion that cryptogamic species are so variable, that it is impossible to circumscribe them with specific characters; and, to be studied with certainty,

* Berk. in Gard. Chron. 1849, p. 467.

they must be studied in the herbarium. The practised eye will there detect similitudes between widely different forms which no definition could convey. Now there is certainly much truth in this notion, but more perhaps, from the wrong conception of authors than from the intrinsic difficulty of the case. So long as essential characters are neglected, and fleeting external characters put in their place, difficulty must needs exist, and the student will never be certain that he has come to a correct decision till he has seen an authentic specimen, or compared his own decision with that of other botanists as manifested in extensive herbariums. A state of uncertainty is always one of more or less pain, and the temptation to a solution of the difficulty by the supposition that he has made some new discovery, will often present such attractions as to prove insurmountable. Nor will he find it possible, without that mental discipline which arises from a patient study of every detail of structure, and of the various shapes which organs may assume under different circumstances. Without such discipline, like certain German authors of some repute amongst persons uninstructed in the subjects they profess to handle, he will propose a new name for every difference, even such as are manifestly merely temporal and accidental, and, on the contrary, he will unite whole groups which belong to entirely different categories. It would be easy to point out glaring examples, both amongst algologists and mycologists. One of the worst amongst Phænogamists, perhaps, is the erection of that state of the inflorescence of several species of *Cissus*, in which the peduncles are deformed by the presence of an internal parasite (*Puccinia incarcerata*, Lév.), into a distinct genus of Phænogams; though this is not worse than referring the same *Alga* received from different sources to two or more distinct genera, and that not among the lower or more obscure species, where there might be some excuse for such a proceeding, or the association of plants so totally different, as *Puccinia* and *Trichothecium*. Nor is the correct appreciation of species of so little consequence as is sometimes vainly supposed. The only way in which we can arrive at anything like accurate views of geographic botany, or the distribution of plants over the globe, is by a correct estimation of species. If two Floras be formed on different principles— while in the one the species are accurately limited, and forms which vary only in some subordinate point, and not in essential characters, are grouped under one common name; in the other, not only every marked variety, but even accidental variation, is elevated to the rank of a species,—it is impossible to form any correct comparison, and this is the more necessary in Cryptogams than elsewhere, because the species have notoriously such a wide diffusion, and because their technical, though not their essential characters, are so very variable. The great point in all these cases is never to describe from single or imperfect specimens, where there is some form evidently very closely allied. It may not be possible, perhaps, always to avoid error, but a little caution will be most advantageous, both as to one's own individual character as a botanist, and to science in general. And if species are once accurately characterised, there will be far less difficulty than may be imagined as to genera. Nothing is more vain than to run down botanists as mere makers of species, as though it did not take as much knowledge and tact to limit species well, as to ascertain a few detached microscopical facts without deriving any general views from such study, or ever seeing the relative bearing of such observations. The physiologists of the present day, at least too many who have some name in science, are absolutely doing the very thing which they profess to despise in species-makers. A proposer of bad, ill-defined species is no promoter of science; still less is the so-called physiologist who draws from isolated half-observed facts, conclusions which the very next observation may entirely destroy. We may regret, indeed, sometimes the over-caution of the prince of physiologists, but such over-caution is ten thousand fold more praiseworthy, and tends more to the advancement of science, than crude, hasty, and ill-considered theories founded on imperfect observations, because what it does bring forth is essentially a κτημα ες αει, and, even when incomplete, is a sure stepping stone for the acquirement of some further eminence.

20. Before entering into a more particular consideration of the different sections into which cryptogamic plants are divi-

sible, it is necessary to consider how far they are related to phænogamic plants, and whether there is any close affinity between any particular order of the two series, which can, with very great probability, be indicated. Mere cases of analogy have little weight in such a consideration. Such cases are presented by the three natural orders, *Balanophoraceæ*, *Cytinaceæ*, and *Rafflesiaceæ*, on the one hand, and by *Podostemaceæ* on the other. In the latter case, there is a great want of spiral vessels, and the forms of many Cryptogams are curiously represented, but there is nothing about the fructifying organs to cause the least perplexity, and the best opinion is that they are reduced *Lentibulariæ*.* The foliaceous expansion is of little consequence. All such productions are mere offsets from the axis, whether horizontal or vertical, which are often dispensed with altogether, insomuch that, as regards a question of this kind, the Schleidenian doctrine, that "plants have no leaves," is perfectly true.† The Rhizanthous order mentioned above, in habit, parasitic mode of growth, and substance, bears a close resemblance to Fungi. If, for instance, a *Pilostyles* be compared with such Fungi as *Podisoma* and *Cyttaria*, which grow upon living branches of Juniper and Evergeen Birch, producing a new crop year by year from the old mycelium, there is a striking resemblance in the way in which the individuals are dotted over the stem. In the fungus, however, there is not a doubt that the threads of the mycelium penetrate the cells of the matrix, and burst forth in the shape of new individuals. Mr. Brown failed to prove that this was the case in *Pilostyles* ;‡ but even supposing that he had been able to show that the rhizoma crept under the bark, and pro-

* Willdenow referred two genera to Cryptogams, *Blandovia*=*Apinagia*, and *Dufourea*=*Tristicha*, the former to Hepaticæ, the latter to Ferns. Mag. der Ges. Nat. Freunde, zu Berlin, vol. iii. p. 200, and vol. vi. p. 63.

† Such expansions may or may not have vascular tissue. In the former case, they would be mere offsets from the bark. It is obvious that the possible or actual formation of a bud in the axil of each leaf, is favored by the presence of vascular tissue.

‡ When Mr. Brown was preparing his memoir for the Linnæan Transactions, he was so kind as to show me his specimens, and to have some conversation on the analogous points in *Podisoma*. His observa-

truded new buds, their development would be little more than what takes place in those phænogamous plants, in which adventitious buds are formed from the roots; and I have sometimes thought that I have been able to trace the same thing in the common Misletoe, as to the affinities of which there can be no question. If it could be proved that such genera give out a true mycelium, consisting of distinct mucedinous threads, uniting at length in more or less solid cords or expansions, and then, without the neighbourhood of any spiral vessels, throwing up flowering buds, it might at once be pronounced that we have a very close approximation to a cryptogamic type. But this is not the case. Spiral vessels may be few, but there are Phænogams of very different aspects and affinities, in which they are equally or more deficient. When the flowers are examined, we find a regular division of the perianth as in other Endogens, a distinct pistil and anthers, ovules on parietal placentæ, and a distinct embryo* not more minute than in many other cases, and the division into Cotyledons not more obscure than in some other parasitic genera, which have evident connection with other plants which bear no relation to Cryptogams. In *Cytinus* and its allies, we have nearly the same condition of matters. That the seeds should be buried in pulp after a time is no indication of inferiority. The true disposition of these organs can, in many cases, be discovered only in the earlier state of the germen. In the case of *Balanophoræ,* though we have still a great analogy to Fungi, the moment the substance of any part is divided, all doubt as to any affinity ceases; and if the stems and their connection with the matrix be examined we are at once convinced that we have no such type before us. A certain similarity of colour, and the absence of green tints, in addition to the habit, give a fungal

tion that plants of the same sex, where the sexes are distinct, occur in patches on the matrix, is perfectly consistent with the view taken in the succeeding paragraph of the text.

* Miers asserts that there is no embryo in *Triuris,* but Dr. Lindley very properly remarks that the body in question is rather an exalbuminous embryo, than an exembryonic albumen. Compare, however, the whole of Miers' remarks in the Vegetable kingdom under *Triurides.*

appearance to these plants; but, on the other hand, not to mention the total difference of the fruit, their slow growth,* and the extreme difference of texture separate them. There is, indeed, often the same volva-like dehiscence as in *Geaster*, something similar to which exists in *Marattia*. This seems, however, merely an exaggeration of what takes place constantly in the formation of adventitious buds and roots, to which it is really more nearly related, than to the more obvious resemblance of *Geaster*, for in that case the whole of the resemblance is confined to the separation and rupture of an investing cellular substance. There is no question about vascular tissue here; the stems are not formed on an endogenous type, and the mode in which the vascular tissue of the shoot originates, as compared with that of the matrix, is precisely that of adventitious buds as compared with the especial portion of the vascular system to which they belong. In this case, the vascular tissue of the matrix appears to exercise the same influence as it would do if the branch was merely a shoot from itself.† It is very true that the floral envelopes resemble closely those in some *Hepaticæ*, a circumstance which occurs also in *Podostemaceæ*; this certainly is of such a nature as to prevent our saying that Cryptogams are always destitute of such envelopes, but it does not show the slightest affinity. The presence of paraphyses undoubtedly affords another point of resemblance, but this is of no great consequence, as analogous bodies exist in many cases of crowded inflorescence. I cannot perceive any essential resemblance between the ovaries and pistillidia of mosses. The pistillidia of mosses, in fact, reasoning from the structure of Club-mosses, if they can be said to be homologous at all, which I do not think to be the case, are not homologues of the ovary, but of the embryonic cavities or corpuscles of Conifers, and therefore must be mere analogues of the ovaries

* *Ombrophytum*, however, is said by Pœppig to spring up suddenly after rain, and is eaten like Mushrooms. Hook. fil. in Lindl. Veg. King., p. 90.

† Similar observations have been made in *Orobanche*. The memoir on *Balanaphoræ* lately read by Dr. Hooker before the Linnæan Society must be consulted on this subject.

of *Balanophoræ*. Our information at present, with respect to all of these plants, is very imperfect, but it may be asserted, without fear of contradiction, that the better we become acquainted with them, the more distinctly their want of affinity to Fungi comes out.

21. Such genera again as *Lemna*, at first sight, may seem to have some claims to relationship, and indeed the species are included amongst the Plantes Cryptogames du Nord of M. Desmazières ;* but as every plant in the first instance is destitute of vessels, and myriads of perfect embryos, we can lay little stress upon this point, when the indications of the fruit are as distinctive as in any other genus. And in point of fact, spiral vessels occur abundantly in *Lemna polyrrhiza*. The resemblance between *Lemna* and *Riccia* is entirely confined to the foliage, and the mere fact that one may be taken for the other, is only one of those curious instances of analogy which present themselves in every part of the vegetable kingdom. A superficial glance is often at fault, when the slightest examination of structure at once sets aside all doubts. Other aquatic Endogens might perhaps be mentioned, but their resemblance is far more slight, and their want of relation still more evident.

22. We now come to a very important subject, the supposed relation between *Coniferæ* with other Gymnogens, and some of the higher Cryptogams. These views are, I believe, as unfounded as those which have been stated above, and instead of giving a deeper and larger insight into real affinities, as is sometimes supposed, they tend, as I conceive, rather to contract the mind in a general view of the vegetable world. Nature does not make sudden leaps, and though in plants of very different affinities points of resemblance may exist, they are not to be estimated at more than their proper value. There is no single point at which the two great circles of the relations severally of Phænogams and Cryptogams can be considered as so perfectly coinciding as to intimate any marked transition from one class to the other. Individual points of resemblance may be discerned, but such as to show no close

* He did not, however, intend to intimate any affinity between these plants and Cryptogams.

relation, nor such as in any morphological view of the origination of one set of beings from another could at once indicate the possibility of change; as for example, from a cup-shaped to a mitræform fungus of very close affinities, by the mere retroversion of the cup, and the consequent confluence of its under side with the stem. (Fig. 13.)

Fig. 13.

a. *Helvella Esculenta*, from a British specimen communicated by Mr. Frederick Currey.

b. *Helvella elastica*.

c. *Peziza macropus*.

23. Except in the depauperation of the floral envelopes, a point evidently of little comparative importance, since we see that the nobler objects of the vegetable world are most frequently those whose floral envelopes are the least developed, it would be difficult to point out one single particular in which Conifers are inferior to other arboreous Exogens. The very slow development of the fruit should, on the contrary, seem to indicate superior dignity. It may be true, indeed, that spiral vessels are comparatively rare in the trunk, but then the presence of these in abundance is no sure evidence of superiority, and even admitting their infrequency to be a mark of inferiority, the wood cells are more complicated

than in many other plants.* But though spiral vessels are comparatively unfrequent in the aerial portions, the little processes which terminate the roots in very many species as first observed by Dr. Hooker, and, indeed, where no such swellings appear, the external cells of the rootlets abound in spirals very much after the fashion of those which are so conspicuous in the aerial roots of Orchids.† That such tissue, when young, is very active, there can be no doubt, but after a time, it merely contains air, and sometimes, as in *Trichia* and *Hepaticæ*, answers the subordinate purpose of opening and closing the peridia by mere elasticity. And it is possible that some secondary end, as the securing a channel for the passage of air under strong pressure, may be answered even in plants of the firmest structure, in which the yielding of such tubes, and their return to their former calibre, may be of consequence. Some purpose of this kind is certainly effected by the tracheæ of insects, which are so like to spiral vessels in appearance, as to suggest some similarity of function. The functions, however, of spiral vessels in vegetables are so obscure, that we can deduce little from their presence or absence. They cannot be in themselves indispensable, or such enormous trunks as are presented by some Conifers could not exist; and whatever their function may be,

* A spiral structure is very visible in the wood cells of the Yew, and, as mentioned above (p. 8), in the white Spruce drift wood of the Arctic Regions. Dr. Hooker has shewn that the close tissue produced at the end of the year is eminently spiral, while the peculiar pine tissue is produced only when vegetation is in full vigour, intimating the latter to be more perfect than the former. See also Berendt Org. Reste im Bernstein, tab. 2, fig. 7, 12.

† Specimens of roots of *Dacrydium* and other Conifers have been long since sent from Australia and New Zealand, laden with these processes. The specimens were sent as parasitic Fungi, but a very slight examination was sufficient to shew that they were really part and parcel of the root. Dr. Hooker's attention was drawn to them accidentally, and he communicated to me his observations on their structure, which I was able completely to confirm. Afterwards we found similar bodies on most of the Conifers cultivated at Kew. I have lately ascertained that the structure is figured in Hartig Lehrbuch der Pflanzenkunde, tab. 18, a work which is apparently in very few hands in this country.

their absence may be compensated by large intercellular apertures, and there is no reason why the same or similar ends, produced by more simple means, if perfectly accomplished and productive of as important results, should be entitled to less dignity than more complicated processes. We see at once that a heart consisting of one auricle or ventricle is inferior to one presenting two, but then the ends to be accomplished in the latter case could not be accomplished by the simpler means, and we have nothing to show that the trunk of a Conifer is in any respect inferior to that of any other Phænogam. The production of a multitude of embryos in the same embryo-sac, again, is scarcely comparable with the analogous phænomenon in animals, for in vegetables some that have the highest dignity are the most productive; the multiplicity, therefore, of embryos is rather to be considered as a mark of perfection, especially when it is remembered, that the seeds of Conifers are as perfectly formed as those of any other phænogamous plant. Where there is some external form upon which to build a comparison, as in Club-mosses, and the large fossil *Lepidostrobi*, there is such an utter want of accordance between the mode in which certain similar effects are attained, that there is, as it seems to me, no question as to affinity.

24. It is desirable, before entering further on the argument, to say a few words on one or two points which are necessary to its perfect apprehension: and the more so, because the view I take is not that of some of the highest botanical authorities, much less of those who have had no opportunity of studying the matter deeply, and are, therefore, likely to be fascinated with the specious arguments and outward resemblances which, at first sight, may seem to indicate that the relation between Phænogams and Cryptogams is far greater than I am myself able to allow. I shall endeavour to explain my view as simply as I can, and with as little use of technical language. Without some previous knowledge of vegetable physiology, it is not very easy, however, to see the true bearings of the question.

25. It will, in the first place, be useful to the student to illustrate, in a simple manner, the terms analogy, homology, and affinity, as they are necessarily used very often, and as fre-

quently confounded by the student. Analogy, in the first place, indicates certain resemblances between things, whether similar or dissimilar in nature. A large portion of poetical images are derived from such resemblances. These may be more or less remote. The old Pythagorean notion, for instance, that an egg is a microcosm representative of the earth, in which the shell answers to the earth, the white to water, the yolk to fire, and the bubble of air at the end to the atmosphere, is a case of very remote analogy. The notion, again, of the elder Agardh that a bird is an analogue of the world (like it, it moves freely through space ; the feathers are the trees which grow out of it, and the parasites amongst the feathers the animals which move amongst the trees), is a case of rather closer analogy than the former, but still very remote and fanciful. There is not a particle of affinity, of course, in either case. Analogy, however, may exist between things which have a closer relation to each other The wings of an insect, for instance, have a certain resemblance to the wings of a bird ; their function is the same, but they are not modifications of the same organ.* The tracheæ of insects, again, have the same function, in all probability, as the spiral vascular tissue of plants ; but they can scarcely be said to be the same organ. The fovilla of the pollen tubes of Phænogams has the same function as the spermatozoids of Cryptogams, but they are not the same organ. These, then, are so many cases of likeness of function, without any similarity of origin or essence, and they are, therefore, cases of analogy, and the objects themselves are called analogues of each other. There are likenesses, too, where there is neither identity of origin nor function. Such likenesses may be general resemblances, as that of certain galls to Fungi. The one are sometimes exact counterparts of the other, but the resemblance begins and ends there, and leads to no important conclusions. Exactly in the same way there may be two extensive genera, not in the least

* The palpi of spiders have, in all probability, the same general functions with those of insects, but there is a generative function superadded. In one sense, then, they are homologues, in another, analogues.

related to each other, in which striking resemblances may exist between certain species of two or more series. Such resemblances may be purely accidental, or they may be part of that harmony of the works of Creation, in which certain likenesses seem to blend the most dissimilar organisms into one connected mass; "a mighty maze! but not without a plan." No one supposes, for instance, that there is any relation between those twig-like caterpillars which deceive their enemies, or the leaf-like wings of the *Mantis*, and the objects which they resemble. These examples are, in a lower sense, cases of analogy; but, in a higher sense, we understand by analogy those cases in which organs have identity of function, but not identity of essence or origin.

26. In deeply studying the relations of organised beings, it is necessary to study the changes which the same organ undergoes in different individuals. Such considerations constitute what is called morphology. The organ itself may, evidently be the same, and yet the functions of it may be wholly different. If, for instance, we study the mode in which pollen grains are developed within the mother-cells, and compare it with the development of the spores in the higher Cryptogams, there cannot be a doubt that the organs are similar in origin, though the functions are totally different. The spores germinate in precisely the same manner as the pollen grains, and, in some cases, from definite points; the end of this germination is, however, totally different; in one case it is the growth of the new individual, in the other case the impregnation of a cell. Such bodies, then, are homologous; they are identical in essence and origin, but dissimilar in function.* The spores of the Cryptogam, on the other hand, and the seed of a Phænogam, have, to a certain extent, the same function, but they have no resemblance of essence or origin; they are, therefore, analogous, and not homologous. These distinctions, when once fairly grasped, are of immense importance in estimating the rela-

* The primary spores of such parasitic Fungi as are represented, fig. 6, originate in a totally different way from the spores of the higher Cryptogams, and though they germinate at definite points, can be only considered as analogues of pollen grains.

tions of organised beings; and we may, therefore, define analogy to be resemblance of function; homology, correspondence of structure or origin.*

27. The word homology, it will be seen then, is more confined in its use than analogy; for we can scarcely limit the latter word within the bounds just prescribed, except where it is the correlative of homology. Homology relates, for the most part, to organs; analogy to organs and to organisms. Now resemblances of very different kinds may exist between such organisms. They may be similar to each other in many respects, and yet there may be no positive relationship between them. Organs may be homologous with perfect organisms, as the tissues of plants with some of the lower Cryptogams; but there can be only remote affinity between them. There can be no intimate affinity where the one class, order, or species, does not approach, in nature, close to another; there must be an identity in the most essential characters, or such a gradual melting of the one into the other, as makes it difficult to say where the distinction ends and begins. Lichens, for instance, so gradually pass into fungi, that it is almost impossible to say to which division certain species belong. In such a case it would be foolish to deny that there is a very close relationship. The resemblance is not one of mere analogy. On the other hand, though there is an intimate homology, up to a certain point, between the several organs of which a lily is composed, and a water lily, there is no affinity between them, except so far as they are both members of the Phænogamic class. There is homology † of organs; there is analogy in the one plant, as a whole, compared with the other, but there is no affinity. These principles will be found of great consequence in the comparison which we shall shortly have to institute between certain Cryptogams and Phænogams.

28. Analogy, then, indicates resemblance between objects which have not necessarily any close affinity; such resemblance may be of greater or less importance, but it is always liable

* See Carpenter's Principles of Comparative Physiology, Ed. 4, p. 6.

† Perhaps the nearest synonym to *homologous* is *correspondent*. But as bodies may correspond, both in function and structure, it is obvious that the word is not sufficient.

to seduce an inattentive or ignorant observer into wrong notions as to the relation of the beings between which it exists. Resemblances of this kind were, at one time, carried to such a point by the Okenists and other German philosophical naturalists, as to involve everything in a cloud of mystical obscurity, like that in which divinity is shrouded by the Hutchinsonians. Homology is of far more value ; for when true it is founded on a deep knowledge of structure, and is indicative either of close or remote relation, while analogy does not necessarily indicate either the one or the other. Affinity expresses the fact that organisms are related, and is of various kinds ; it may be no more than that between one being and another simply as organisms, between the members of distinct divisions, or between those divisions themselves : but when one being, or class of beings, is said to be allied to another, it is generally meant that the peculiarities by which one is distinguished pass gradually into those of the other. It expresses immediate relationship and not remote connection.

29. An excellent view of the relations of analogy and affinity has been intimated to me in writing by Dr. Hooker. He says, that the difference between analogy and affinity depends mainly on affinity being betrayed by attributes which are as prominent at the earliest period of growth as at the latest, and often more so ; but the contrary holds good of analogy. Thus the hairs of the capitula of *Balanophoræ*, and the paraphyses of mosses are perfectly similar, but this circumstance shows no affinity between them, for they are modifications of what are fundamentally different organs. If the first development of the Mammalian ovum be compared with that of an *Hæmatococcus*, it will be impossible to deny the close resemblance, and that both take place on one plan. The relation, then, between the highest Mammal and the obscurest Alga, though almost infinitely small, yet certain, is capable of being ascertained only in these first stages of development. The relations, again, of plants with central placentation to others with parietal placentæ may be obscure. Not a trace of the latter structure is to be found in full-grown Cloveworts, or even where the carpels are normally developed. But a monstrous state of

the common carnation and sweetwilliam has given at once the clue.* The ovules in this monster are replaced by carpels more or less distinct to their base, and, in this condition, the placentation is as truly marginal as in any Phænogam; and whatever affinity there may be in the matter is prominent only when the plant is reduced to its fundamental condition. In other conditions the real relations of the parts are obscured. Multitudes of similar cases might easily be brought forward in confirmation of the law. It is to be considered, moreover, that every observer differs, not only in the estimate of false affinities, but in the amount of likeness from which they start. Homologies, when once established, are certain, and must be estimated by every competent authority at the same value. *Andræa* affords an excellent example. It is a moss in everything except the dehiscence of the theca. There is an analogy between this and the quadrifid capsule of *Jungermannia*, but there the likeness begins and ends. The likeness is visible only in the last stage of growth. If it were a case of affinity it should be visible at once. There would have been a development of elaters or something homologous within the theca as in *Jungermannia*.

30. It is desirable, again, before entering further on this argument, to say a few words on the reproductive organs of Cryptogams, at least on the female organs, for there is little or no similarity between the male organs of Cryptogams and Phænogams. There are no proper pollen globules, no germinating of a cell to bring the walls in contact with the embryo-sac, nor is there any agreement between the mode of generation of the grumous matter or fovilla and the spermatozoids.

In the more simple cases there is nothing at all analogous to flower, but certain privileged cells are separated from the threads or compact tissue of the matrix, whether naked, or produced within a special tube or sac, and constitute the fruit. These germinate almost exactly like pollen grains, and reproduce the species. There are, sometimes, several kinds of spores upon a plant, all capable of reproduction, though differing in appearance. These spores, then, are homologues of the individual cells

* See Gard. Chron. 1850, p. 612; 1855, p. 280.

of Phænogams, which, at times, are equally capable of reproduction in the shape of buds.

31. The spores, or what have the appearance of spores, do not always reproduce the plant immediately, even in plants of such a low grade as Fungi. In the higher Fungi, certain cells swell and become clavate, producing on their surface a number of little points, each of which is terminated by a spore. In *Tremella*, this clavate swelling has much the appearance of fruit, but the points upon its surface are greatly elongated, and true fruit at last is produced. In certain cases, these spores produce from their surface minute processes, supposed by Tulasne* to be male organs. These can only be seen with a nice adjustment of the light. Their existence has been verified by myself and Mr. Broome; their functions, however, at present must be considered doubtful. In the gelatinous fungus, which is so common on Juniper, *Podisoma* (Fig. 6*a*), the bodies I have represented are very like these sporophores in Tremella, but they germinate truly like other spores, and are remarkable for germinating at definite points. The

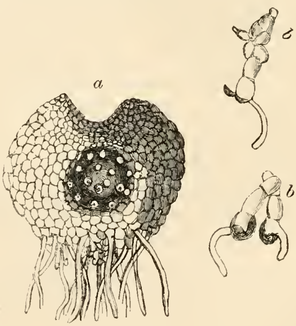

Fig. 14.

a. Germinating spores of *Nephrodium marginale*.

b. Prothallus of *Gymnogramma chrysophylla*, as seen from below, shewing the antheridia and archegonia.

From Henderson in Mag. of Zool. and Bot. vol. i. p. 333.

* Tulasne in Ann. d. Sc. Nat. Sér. 3, vol. xix. p. 193.

threads they put out produce in fact the true fruit. This holds good equally of all the blight or rust like Fungi, such as affect corn and other living plants.*

32. A different order of things prevails amongst the higher Cryptogams. The spores germinate and produce a more or less foliaceous mass, which after impregnation bears fruit containing bodies like the original spores, or a plant capable of bearing such spores, in which case it is called a prothallus. (Fig. 14.) After a time, certain pitcher-like processes project from it, or are sunk in its substance. A cell at the base of these urns, when impregnated, grows after the fashion of the first cell of the embryo in Phænogams. In some cases, then, the cells which arise from germination are developed, as in mosses, into a plant directly, reproducing spores by which the cycle is again accomplished ; in others, as in Ferns and Club-mosses, an embryo more or less resembling those of Phænogams is first generated, which strikes root and sends out an ascending stem, which sometimes grows into an enormous tree, producing every year a crop of spores. The spores, then, in these different plants are of very different values, and in no respect homologous with the seeds of plants. Cryptogams have, in fact, no true separable seeds,though, in the highest forms which they assume, they generate an innate embryo. Without some such notion, though I am obliged to anticipate matters to be described more fully hereafter, it is scarcely possible to estimate the true relations of Cryptogams to Phænogams.

33. I shall proceed now to explain the points of difference and resemblance which exist between Club-mosses and Conifers, for if any Cryptogams are allied, it must be these.† *Selaginella*, for example, produces two kinds of spores, a smaller and a larger, in closed processes. Externally, and in their mode of generation, both these resemble the spores of allied Cryptogams, but

* This seems to be a sort of alternation of generations. The first cycle is completed by the well-known reproductive bodies ; the second by the spores produced on their germinating threads.

† For figures illustrative of the text look forward to the section on Club-mosses. For full information, Hofmeister's two Treatises must be consulted.

the smaller ones are not of the same import as the larger. *a.* The smaller spores which consist of a single cell, within a proper envelope, remain some months after being sowed without much change. Gradually, however, their protoplasm generates a number of cells, each of which contains a spiral spermatozoid. The smaller spores, then, which do not germinate, are analogues of antheridia, though they resemble in their mode of development ordinary pollen grains, which are clearly homologues of spores. They are, in fact, of far greater dignity than the pollen grains of Conifers, though, in point of fact, homologous with them. The grumous fovilla of these latter, in every respect except in function, differs from the ultimate contents of the small spores. *b.* The larger spores consist also originally of a single cell, but in the process of growth they acquire an envelope, and have a disc applied to their inner surface consisting of a double row of cells. This exists while they are yet in the mother-cell from which they are derived. The formation of this disc is the only thing in the shape of germination which they exhibit. After some months, a similar disc is formed within this, and the upper disc contains a number of little flask-like bodies, communicating above with the open air, in which, by impregnation, an embryo is developed from a single cell filling the base of the body, which is called an Archegonium. I am not aware that the formation of the embryo-sac within the nucleus of Phænogams has been observed accurately.* It is quite certain, however, that it is not a mere cavity formed in the cellular tissue of the nucleus, for if so, it would never become free and project beyond its aperture, as it does in Crucifers, much less would there be a plurality of such sacs as in the same plants, sometimes branching and assuming a variety of forms.† We have here, then, a plurality of embryo-sacs, a tendency to become free, and at the same time to germinate. We do not know how these multiplied embryo-sacs arise, whether from the division of one cell, or the swelling out of distinct con-

* Schleiden says that it is the dilatation of a central cell, and such it probably is. A direct proof of this is evidently one of extreme difficulty.

† Tulasne in Ann. d. Sc. Nat. sér. 3, vol. xii. p. 21.

tiguous cells. There is not, however, I think, sufficient to justify us in considering the large spore of the Club-moss as homologous with the embryo cell of Phænogams, allowing as much weight as possible to the facts. These large and small spores are identical in origin, notwithstanding their difference of size. Both, therefore, are homologues of pollen grains, but we have no example of a pollen grain producing an embryo in its protoplasm, though the cells of anthers, like other cells, may be capable of development into buds. The embryo-sac, then, in the Conifer, after many months is slowly filled with endosperm; cavities are formed at the apex, in addition to the large central cavity; particular cells in these little cavities or corpuscles divide, giving rise to a bundle of threads, and after impregnation, the tips of these threads produce the embryos, with the radicle pointing to the aperture of the nucleus. Now, if the progress of the spore of the Club-moss be followed, even allowing that it is the homologue of the embryo-cell, the disc ought to be the homologue of the endosperm; but then if it were so, the whole leafy plant of a Moss or Liverwort, which is clearly homologous with the disc of the Club-moss spore, must be equally the homologue of the endosperm, which is so clearly absurd, that at once all notion of homology ceases. Allowing then the disc to be analogous to endosperm, the archegonia are analogous to the cavities or corpuscles at the upper part of the endosperm of Conifers.* The central cell of the group, of which in the early stage the archegonia consist, is analogous with the cavities of the corpuscles. A cell is similarly formed from its protoplasm, but then the development of this is quite different. Up to a certain point there has been considerable resemblance, but now, with strong analogy, there is essential difference.

34. In the Club-moss, a single cell at the base of the archegonium divides; a process is formed upwards, analogous only

* It is sometimes said that these bodies in Conifers are without example in other orders, but they are, possibly, only modifications of the suspensors, as in *Scrophularia*, from the swollen end of which the embryo finally grows.

with the suspenders of the embryos in Conifers ; for this process remains much in the same condition afterwards, while the lower half of the basal cell, which was really and immediately the embryonic cell, at length forms by division a cellular mass, or, in point of fact, a true embryo, with the radicular end pointing one way, and the foliiferous end another. The order of the formation of the cells from which the embryo is generated, is exactly contrary to that which takes place in Conifers; the radicle is not continuous with the suspender, and does not point to the apex of the sac. There is, however, a semblance of two cotyledons, and besides the fact of numerous cavities existing in the same disc, analogous with albumen, occasionally two embryos are formed in the same cavity. It must not, moreover, be concealed that a bundle of spiral vessels passes from the trunk into each leaf, and that there is a disposition to form adventitious buds in consequence in the axils of the leaves approximating the plant to Phænogams, insomuch that any fragment of the stem will grow. In *Marsilea* the spores resemble still more closely the embryo-sac, for they are ultimately filled with cells. In other cases, the cellular mass resulting from germination loses every resemblance to endosperm, and, in fact, forms the plant, on which fructification is developed by means of archegonia, essentially the same as those of the Club-moss, in the first instance, but very different as to the results. In the Club-moss an embryo is formed which reproduces the species; in the Moss, a theca is formed which contains spores for the reproduction of the species. The fertile cells in the archegonia, in the two cases, were perfectly homologous, but the productions of those cells, though still homologous, have only remote affinity; the closer affinity was shown at an earlier stage of growth.

35. What, then, is the relation between such Phænogams as Conifers, and such Cryptogams as Club-mosses? There is not the slightest transition from the one to the other, though certain resemblances, indeed close analogies, exist, and there is some outward conformity in the results. The ends, however similar, have here been produced by very different means, and the several steps by which the similarity has been produced, arising gradually from the simplest organism, are

such that all question of affinity seems to me to be at an end, however enticing the points of resemblance are. Conifers are highly-organised Phænogams, and Club-mosses are the most so of Cryptogams; but if we take into consideration the immense difference of general structure, and much more of manner of development, without our being able to point out any intermediate plants whose relations on either hand are doubtful, I do not see how we can venture to say that there is any affinity.

36. Transitions from one group to another may take place in various ways; as, by the union of the characters of two osculant groups in a single species, so as to make it doubtful to which the species belongs, as, for example, in the transition from *Uredineæ* to *Tremella;* by the sudden alteration of the mode of development of some particular organ, as in the spores of *Equiseta* and Ferns; or by the mutual interchange of many characters, as in Phænogams. In the monopetalous hypogynous orders, as, for instance, in *Scrophularineæ*, *Solanaceæ*, *Acanthaceæ*, *Bignoniaceæ*, and *Convolvulaceæ*, which are so intimately related that they can neither be technically divided nor arranged in a linear series, we have an excellent example, and so with *Apocyneæ*, *Gentianeæ*, *Loganiaceæ*, which are similarly connected, not only with one another but with some of the above, and even no less intimately with the Epigynous orders, *Rubiaceæ* and *Caprifoliaceæ*, as has been shown in an admirable paper of Mr. Bentham's, lately read before the Linnæan Society. Between Conifers and Club-mosses there is no such connection. By a curious diversity, the spores which immediately reproduce the species in the greater part of Fungi, give rise to a sort of prothallus in the rusts and wheat mildews. Here, then, is a slight foreshadowing of the new series of developments in higher Cryptogams, in which the spores produce a prothallus, and, in so doing, at length, by a wonderful chain of analogies, simulate the formation of embryos in Phænogams. The Club-mosses, and especially the *Lepidodendra*, are probably the highest limit capable of being reached by Cryptogams, and their mode of fructification the nearest to that of Phænogams. But there is no connecting

link, and therefore no affinity. We have merely two parallel series, of which the results are, to some extent, the same. A great advance has certainly been made in the Cryptogam; a true embryo has been formed; there is, to use a German phrase, a greater differentiation of parts; but, after all, there is a wide and impassable gulf, between the two, and in the absence of all evidence of a bridge passing over the gulf, it seems to me unphilosophical to allow any close affinity.

37. It has sometimes been urged that there is a prothallus in Conifers which brings them near to Club-mosses. If there is any prothallus it is the endosperm, and that certainly has the same functions and the same signification in Conifers as in other plants, though it may be more completely developed before the formation of the embryo than elsewhere. The suspensors in other Phænogams are possibly the same organs with the corpuscles of Conifers, or, at least, analogous with them.*

38. But it may be well to look to one or two more points in Conifers as regards comparative dignity. The slow development of the fructifying organs, and the curious phenomena in the pollen grains preceding the protrusion of the pollen tubes, seem to be proofs of superior dignity. The highest recent Cryptogams are doubtless the Club-mosses, in which the process is extremely slow; the moulds, on the contrary, fruit and reproduce their species within a few days. In respect to the naked ovules, there is little difference between impregnation by means of a stigmatic tissue and immediate impregnation through the micropyle. There is precisely the same process in both when once the pollen reaches the micropyle. The only difference is in the preliminary act. It is not, perhaps, quite so clear that impregnation may not take place sometimes without the intervention of a stigma, even in plants which possess that organ. Pollen grains must sometimes fall upon the micropyle of the naked ovules of *Reseda*, and as they may be made to germinate†

* If these suspensors are deduplications of the embryo-sac, the correspondence of the corpuscles and archegonia is far less striking.

† Reissek Act. Nov. vol. xxi. P. 2, p. 469.

artificially, it is conceivable that the pollen tube may, in certain cases, penetrate, or, at least, come in contact with the embryo-sac, quite as easily as by means of a stigmatic tissue. Dr. Hooker has lately made some experiments of cutting off the stigmatic rays of unimpregnated poppies, and yet has obtained perfect seeds.* It is alleged that direct impregnation is a sign of inferiority, resembling as it does what takes place in many reptiles. But the whole matter of impregnation is so very different in animals from the correspondent process in the higher plants, that no weight can be attached to such a resemblance. Cryptogams might be considered of superior dignity to Phænogams, for example, because of their spermatozoids. The result of impregnation in the case of lizards is, in many respects, far inferior to animals produced from more normal impregnation. But as much cannot be said of Conifers, nor do I think them at all degraded, because impregnation does not take place without the intervention of a stigmatic tissue. In many reptiles, impregnation is as precarious as in trees with distinct sexes, the water in the one case being the vehicle, in the other the air. Besides, in *Gnetum* and *Ephedra* there is an organ developed which performs the functions of a stigma, though not arising from the placenta ;† but even supposing it to be wholly inoperative, it is at least representative, like the mammæ on the breasts of male quadrupeds, which do occasionally contain milk as in the female. It is not, indeed, quite clear whether the simpler mode, judging by analogy, may not be of the higher dignity. No one would pretend that in those cases where the impregnating substance is stored

* Hooker in *Gardener's Chronicle*, 1855.

† Much, of course, depends upon the fact, whether impregnation is effected before the formation of the envelope, which bears the pseudostigma. The argument would be stronger if the older views of the structure of the flower were correct, which, on examination, appears to be the case; the envelope in question is external to the nucleus, and therefore the processes cannot be the same with the curious bodies which occur in *Thuya*. In *Larix* the stigmatic cells, as figured by Geleznoff, Ann. d. Sc. Nat., Sér. 3. vol. xiv. tab. 13, fig. 15, 16, whose paper may be consulted respecting the peculiarities of the pollen in Conifers, are equally independent of the placenta.

up in certain vesicles,* after deposition by the male, as in *Aphides* and *Gryllus*, there is any indication of higher dignity, though the process is more complicated; but even granting that the naked ovule may be the less perfect organ, the whole system of vegetation is so entirely different from that of the highest Cryptogam, that I am unable to see a particle of affinity, nor, indeed, in the vegetable world, as at present known, am I able to trace any close connection between Phænogams and Cryptogams, look which way we may. Both, indeed, are vegetables, and both have certain points of resemblance, and similarity of organs; but in everything which regards essential character they are altogether distinct, as, on the other hand, I am inclined to think is the case with the two great divisions of Endogens and Exogens: there may be some difficulties as to the order of development, but still, in every case, the grand distinctive points remain fixed and certain, and the separation of such plants as *Tamus* and its allies, under a distinct order, serves only to confound distinctions which appear to me absolute.

39. One fertile origin, indeed, of such notions as to the close relation of organisms in reality so widely divided, depends on the prevalent idea that there are no such things as definite groups in nature. All, it is said, pass into each other by insensible gradations. It is necessary, however, to have definite notions of the typical characters of families. It is true certain characters may be common to two groups, but this does not prove affinity. There is a definite distinction between endogenous and exogenous growth, between a Monocotyledon and a Dicotyledon, between a Phænogam and a Cryptogam; and though there may be modifications of these distinctions, yet these modifications often take place at points as far as possible distant from each other; not where endogenous and exogenous plants might be supposed to be confluent. Dictyogens, for instance, are supposed to approach Exogens in their leaves and in the arrangement of their tissues, but their embryo and the development of their wood are as distinctly mono-

* Lespés Mémoire sur les Spermatophores des *Grillons*, Ann. d. Sc. Nat., Sér. 4, v. iii., p. 366.

cotyledonous as in plants which represent the typical structure of the stem more completely, and multitudes of similar instances might be alleged.* If *Nymphæa*, again, be taken, the embryo, when properly understood, is as distinctly dicotyledonous as in any other plant; and if further proof were wanted, the germination of the common pæony should be compared with it. Each group of organisms has a circle of its own in which they are combined by close affinities, and these circles are not the less definite, because there may be an osculating point with some other circle. The two great groups of fungi, for instance, characterised by naked and inclosed spores, are perfectly definite. Even in those cases where the inclosed spores are reduced to one closely invested by the outer coat, so as to look naked, the morphology is as definite as ever, and the genus *Haplosporium* in which this character is most prominent is, in fact, one of the noblest, and by no means a form of transition. Except where the naked spore is a secondary form of fruit, there is never the slightest doubt as to the true affinity. It may be true that in *Hymenogaster* a sac is occasionally developed round the spores, but the spores are then as perfect and as definitely placed as in other species where there is no such sac, the presence of which is a mere analogy and not an homology. What, in point of fact, is necessary to the successful study of this or any other branch of science, is to avoid mere speculation; to endeavour to grasp, if possible, the exact meaning and import of every modification which occurs, by close comparison and observation of nature. A person who should set out on an investigation of the phenomena of impregnation in Phænogams, with a decided prejudice in favour either of the Schleidenian notion of the penetration of the end of the pollen tube into the embryo-sac, or of its simple contact with the sac apart from any introversion, would be sure to see facts with eyes already more than half-blinded. If any proof of this were wanting, it would be found in the circumstance that the same identical specimens and preparations have very lately led two different German botanists to precisely different conclusions. The real object

* The truth is, the majority are undoubted members of *Liliaceæ*.

should be to ascertain exactly what the structure is, and then to build upon the observation ; but to place no superstructure whatever on facts which admit of two distinct interpretations, one of which is as plausible as the other. A great degree of caution is wanted, and of good faith too, without which error is inevitable where such delicate and precarious manipulation is required. The Cryptogamic student, if he enters on more than the mere determination of species, will find enough to call for the exercise of no ordinary acuteness. Let him, for instance, strive to ascertain exactly the nature of the communication between the plant and matrix in the parasitic fungi, which belong to the group of rusts and mildews, and he will soon find, if he is wise, that he cannot well be too cautious before he draws his conclusions.*

40. A few words must still be said about Cycads, both on account of the remarkable fact of the circination of the pinnate leaves in many species, and of the deviation from the normal venation of *Zamiæ* in *Stangeria* (Fig. 1), resembling perfectly that of ferns. That there is a resemblance in the vegetative organs here is undeniable, as there is in those of Podostemads to *Hepaticæ*, or of *Balanophoræ* to *Fungi;* and were this accompanied by changes in the fruit at all approximating it to that of Cryptogams, it would have considerable weight. We have, however, as distinct a dicotyledonous embryo in Cycads, as in any Exogen, and perfect pollen. The spermatozoids of Acrogens are so totally different from this latter, and the whole history of their vegetation, that, in spite of one or two points of resemblance, and those not universal, I cannot see here, again, anything approaching to affinity, though there is a foreshadowing of structures to

* In books intended for students, an author cannot be too sure of the facts which he lays before them ; nor be too severe in his application of them. Otherwise his reader will throw down the book in despair, since he can obtain no definite notions from it, or will gradually fall into the same loose way of reasoning himself, and derive no lasting benefit from it. He may cram up its contents for examination, and when they have answered that purpose, they will be put out of mind for ever. He will, in fact, have acquired nothing solid ; nothing that can help him to the acquisition of fresh knowledge.

be met with in a different and inferior series, but not in points indicating inferiority.

41. External resemblance is very often deceptive in tracing the relations of plants to each other, and an utter difference of aspect may be consistent with close affinity. Similar organization will sometimes exist in widely-separated plants, while difference of structure will be found even in plants of the same genus where habit is different. The distinctive mark, for instance, in coniferous wood, which was, at one time, thought decisive as to affinity, is not confined to Conifers. In Magnolias and Witch Hazles *(Hamamelidaceæ)* we have the same structure, whatever pains may be taken to explain it away; and if it is considered that ordinary woody tissue succeeds uniformly to the glandular tissue in Conifers, as the year advances, the one being actually produced from the other, we need not feel surprised that it is not certainly indicative of affinity. Nothing can be much closer than the general appearance of the fruit in Pepperworts and Arads, and if annual stems be examined there are the same scattered fascicles of woody tissue. The inflorescence, indeed, of all is not the same, but this would merely be exceptional were the structure of the stem really identical; but take an old pepper stem and you have strong plates of medullary tissue, and may count the annual rings. Hence, though, up to a certain point, there is endogenous structure (with the exception of the characteristic crossing of the woody bundles), you have the two cotyledons to convince you that such eminent botanists as Blume and Richard have been led astray by analogy, when they considered them as true Endogens. There is, indeed, some question, raised by Blume and Bennett, as to the order of the development of the spiral vessels, but be the point determined as it may, the medullary rays, reticulated articulated leaves, dicotyledonous embryo, and, above all, the germination properly understood, must be decisive as to real affinity. In like manner the Menispermads were supposed to present an endogenous structure, but if branches of sufficient age are examined, there is no question about the case; and even were this not the fact, the whole structure of the embryo would

never sanction any notion of a relation to Endogens. The exigencies of climbing plants, which suffer great compression, require a peculiar arrangement and structure in their component parts. But other instances may be produced equally full of instruction.

42. Take, as a third instance, the pseudo-exogenous growth of the larger Seaweeds and Usneoid Lichens. A transverse section in many of the former presents zones, formed, period by period, corresponding with the development of the laminæ, roots, or branches, as is very visible in the stems of *Lessonia*.

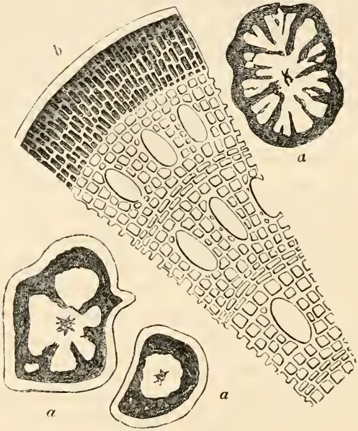

Fig. 15.

a. Sections of *Usnea melaxantha*.

b. Section of stem of *Lessonia*, showing the pseudo-exogenous growth. Both from specimens communicated by Dr. Hooker.

There is no line of separation between the cortical cells and the zoned portion, as though there were at once a centrifugal and centripetal growth, nor are there any wedges of medullary tissue from the central pith, which is so conspicuous. The difference, then, between this and real exogenous growth is very great, and whether the innermost cells of the cortical layer are gradually changed, the terminal cell dividing, or whether increase takes place by the division of the last-formed cells of what may be called the wood, as is the case in Dicotyledons, we have still something very distinct, though bearing a very decided analogy. The latter mode of growth is the more probable, when the similar formation in *Usnea melaxantha* is taken into account. In this case the structure of the outer portion of the medullary substance, which is often at length quite free from the cortical layer, is so loose, though still capable of growth, and of producing, at times, gonidia, that it can increase, independently of the other, and so imitate, very closely, exogenous growth.

43. In *Usnea melaxantha* there is, however, as stated by Dr. Hooker, in the Antarctic Flora, something very distinct from what takes place in other Lichens, as far as is at present known. "Proceeding from the circumference there is, first, a horny coloured cortical layer, answering to what is called the cortical layer in *Lessonia*, and to which, in that plant also, the coloured chromule is chiefly confined: secondly, the layers of intermediate lax tissue, successively deposited, though much more obscurely than in *Lessonia:* and thirdly, the central thread, which is a stout axis answering to the elliptic core of *Lessonia*, but in this Lichen becoming so lax towards the centre as to inclose a cavity in the older stems." Here, again, we have a close imitation of exogenous growth; added to which, in some Lichens, there is often a solution of continuity between the cortical and medullary layers; but no person would pretend that this is any sign of affinity, though it is curious that the laminæ in the *Lessonia* are analogous in their effect to leaves,* and that this mode of growth should be exhibited as at present known only in the noblest of all Lichens. It is quite evident, however, even in species where no zones exist, that increase in size takes place in the same fashion. It is very curious, that in specimens of *Usnea melaxantha*, just received from the Falkland Islands, sections of which are given above (Fig. 15), though there is no such exogenous appearance,

* According to Schulz, in Flora 1853, the zones in the stems of *Laminaria* are developed upwards, and coincident with the development of additional roots.

the central cord, which consists of a hard cartilaginous mass of closely anastomosing threads as in the external coat, is divided into wedges so as to form a further analogue of an Exogenous stem. In process of growth those plates divide, and resemble some of the more anomalous arrangements of the wood in Exogens.

44. The differences of habit, and even of structure, in closely allied flowering plants, are equally deceptive. Take, for instance, the climbing and the erect *Bauhinias*. The flattening or angularity of the stem, in this and in many other genera of the same natural order, as also amongst *Sapindaceæ*, *Bignoniaceæ*, *Malpighiaceæ*, &c., the compression and torsion to which they are subject, and, in fact, the necessities of the plants, induce anomalies in the direction of the medullary rays, the development of parenchyme, the intrusion of cortical matter, &c., which almost defy investigation.* In some species as *Cassia quinquangulata*, Rich., which is not always a climber, there is at different epochs, and under different circumstances, a very different structure,† insomuch that Crüger says expressly, that if, on the one side, perplexity arises from the complication of the wood, on the other hand the differences in individual plants show that a great part of these anomalies may depend on accidental causes, as soil, position, &c. If the office of the ducts be really to carry air to every part of the plant, it is clear that the size of these ducts must be increased in proportion as the stems are subjected to distortion and compression.

45. Take, again, the difference of structure in different species of *Myzodendron*. In *M. brachystachyum*, the wood is deposited in two series of wedges, not always very regular, and at first sight calling to mind, as regards their disposition, some of the climbers mentioned above. In *M. quadriflorum*, the inner series is represented by a single oblique wedge in the axis, while in *M. linearifolium*, there is but a single series. When the disposition of the various tissues of which these are

* See Crüger in Bot. Zeitung, 1850, 1851; Mettenius in Linnæâ, vol. xix.; the Memoirs of Jussieu, Schleiden, &c.

† Crüger, Bot. Zeit. 1851, p 469.

composed, and also the medullary rays are considered, the modifications are greater than would frequently be found in distant genera of the same natural order; but in *M. punctulatum* such a difference exists, that Dr. Hooker, speaking of this in comparison with the other species, says, "that no one, from an examination of the wood alone, would hesitate in pronouncing them to be plants widely separated in a natural system."*

46. It is strange enough to see the medullary rays in *M. brachystachyum* and *quadriflorum*, consisting of uniform tissue, while in *M. linearifolium*, they abound in conspicuous masses of woody cells, which exist also in the bark; but while the pith of other species is simply cellular, in *M. punctulatum* it consists of a dense mass of woody fibres (pleurenchyme), and as a consequence, there are no true medullary rays. Look again at the strange difference which exists between the dry fruit of *Myzodendron*, and the viscid fruit of *Loranthus* and *Viscum*, and the still more marvellous arrangement by which the dry tissue of the former, in the condition of tendril-like threads, clasps the stems of the plant on which it grows, in order to keep the germinating seed in a fit position for the radicle to exert all its force at one point, so as to enable it to pierce the bark, thus answering the same purpose which is secured by the slime of *Loranthus* or *Viscum*. Or again, amongst the same plants, look at the utter diversity displayed by the anthers; the bilocular anthers of *Loranthus*, the unilocular of *Myzodendron* with their central columella, and the cribriform pollen cavities of *Viscum*.

47. The structure of the ovules in *Cryptocoryne*† *(Ambrosinia ciliata*, Roxb.), so different from that of allied plants, will give us another excellent example. The embryo projecting at an early period beyond the walls of the nucleus, the enormous many-leaved plumule thrusting the radicle on one side, the rapid fall of the cotyledon, even before the seeds have left the capsule; but above all, the direction

* Hook. Fl. Ant., p. 297. The whole of the above information is derived from the Antarctic Flora. I have also a beautiful specimen of the wood of *M. brachystachyum* by the kindness of Dr. Hooker.

† Linn. Tr. vol. xx. p. 263.

of the radicle away from, and not towards the apex of the nucleus, are all anomalies which have no parallel in its closely-allied genera. "Nothing," says Mr. Griffith, "can prove more satisfactorily than the present instance, the absolute necessity of tracing anomalous forms back to the earliest period of their development. In this case, the process is attended with the desired effect, viz. of reducing anomalies to the ordinary type of formation. It is very evident that the form of the embryo, immediately before its conical apex projects through that of the nucleus, closely resembles the usual form of these organs in other Aroideæ, since we have a superior radicle,* a cotyledon, and a tendency to the formation of a lateral slit, as indicated by the depressed areola."

48. The best characters are often derived from the germination and structure of seeds, but in nearly related plants, these matters are often very different. In *Pœonia* and *Nymphœa*, we have a germination greatly resembling that of Endogens ; in *Delphinium fissum*, and some other species, there are two cotyledons joined by their petioles, so that the plumule is obliged to force its way out at the base ; a similar structure occurs in *Bunium luteum*, *Prangos ferulacea*,† and *Dodecatheon Meadia*. In some Umbellifers the anomaly is, however, much greater, the two cotyledons are soldered into one, and no plumule is produced, but the energies of the plant are devoted to the formation of a tuber, which sends up a bud in the succeeding year ; this is the case in *Bunium Bulbocastanum*, and in various other genera ; I believe it is the case, also, in *Thapsia villosa ;* in *Corydalis cava*, and many other species, however, a single cotyledon only is produced, and, as in the last case, it produces a bud the following season from the tuber. In

* The radicle is, in fact, pushed aside by the enormous plumule. If analogies are wanted, compare the plumule just when the cotyledon has fallen with *Riccia natans*.

† In *Prangos ferulacea*, the first leaf of the plumule makes its appearance at the point of confluence of the two cotyledons, the others being free. I have availed myself here of an excellent paper, by Bernhardi, in Linnæa, vol. vii. p. 561. See, also, Irmisch, in Botanische Zeitung, 1856.

Leontice there are two cotyledons with, however, a similar formation of a tuber. In *Linaria arenaria*, a shoot is formed below the cotyledons, a circumstance which has been observed also in *Euphorbia Lathyris*, and some other species. In *Cyclamen* the germination is that of *Dodecatheon*, but only the petioles of the cotyledons are developed.

49. It would be easy to multiply such examples to almost any extent, were it necessary to do so. I shall, however, still point out one source of fallacy in the estimation of affinities, which arises from the extreme difficulty of appreciating them till the real clue is found out. Fries, indeed, has shown a wonderful tact in ascertaining the affinities and nature of certain Fungi, but till the true structure of the hymenium was known in the Puffballs, Stinkhorns, Birdsnest Pezizas, and a multitude of other instances, it was almost impossible to arrange them in any natural sequence. The true affinities of such genera as *Nidularia* and *Sphærobolus*, could never have been imagined without some such clue. The same may be said again of the naked-seeded truffles; nothing is more clear than their real nature, now that the structure of the hymenium in the higher Fungi is known; and as regards the truffles with inclosed spores, the discovery of *Genea*, and much more of *Hydnocystis*, which is a mouthless *Peziza*, at once makes the passage from *Tuber* to *Peziza* evident, the one having the rough sporidia of *P. radula*, the other, the smooth sporidia of *P. arenaria*, which is almost hypogeous. Who could guess, at the first glance, or, indeed, without a knowledge of the fruit, that there was any affinity between *Callitriche*, *Hippuris*, and *Onagrariæ*, or, much more Myrtles? Take again the affinity of *Lemna* and *Arum*. There is not the slightest external sign which could lead to a notion of affinity. and the whole structure of the plant is against such a notion. The genus *Pistia*, however, on the most superficial glance, indicates an affinity with *Lemna*. The habit is the same, and there is the same highly-developed pileorhize, which is no special organ, but the same thing with the pileorhize in more complicated plants. The inflorescence is, however, no longer so thoroughly simple. There is a distinct spatha, and a cup-

shaped calyx to the monadelphous stamens, though the male and female flowers are associated; and an ovary with many erect ovules. *Ambrosinia* makes yet another step. The spatha is well developed, and whether or no we consider the ten twin anthers,* as belonging to as many stamens, we have a spadix in the dissepiment, with the single female flower on the one side, and the male on the other. The position of the ovules, however, which is totally different from that of *Pistia*, is a curious instance of anomaly. It is but a step from *Ambrosinia* to ordinary Arads, and thus the affinity of *Lemna* to *Arum* is proved, an affinity which could scarcely have been made out without the intervention of *Pistia;* and when one such affinity of a degraded form is ascertained, there is a clue to other similar affinities. One of the most striking instances of difference of habit, is that between *Cactus* and *Ribes*, an instance which was familiar in the mouths of all, when the natural system first began to replace the Linnæan in this country, and yet no affinity is more sure; and almost equally striking is that between nettles and figs, to which *Dorstenia* gives the true key. On the whole, then, it is plain that immense differences on the one hand, should not at once determine against affinity, nor on the other hand, should striking resemblances mislead us. We must not judge by isolated facts, but, as far as we can, by the whole history and morphosis of plants, otherwise we shall never arrive at affinities; and if this course be pursued, I know of nothing which can confound a single Cryptogam with the lowest Phænogam, and much less with Phænogams high in the scale, like Conifers.

50. It may be a very good answer to the question, what Cryptogams approach nearest to Phænogams, that Club-mosses present the greatest similarity in habit and in fruit. But we cannot ignore the fact, that Club-mosses bear spores like other Cryptogams, which, apart from the plant, undergo a variety of changes, in consequence of impregnation, at a distant period, and at length produce a plant, which springs at once into a new

* See Cesati Ueber die Gattung *Ambrosinia*, Linn. v. ix. p. 281, tab. v. fig. 8, 9.

individual, without any intermediate rest; that impregnation takes place by spermatozoids, and not by a pollen tube; that the embryo grows in an entirely different way; that the radicle does not point to the foramen, and that, after all, the mode of growth in the stem is totally different. When, moreover, we weigh the arguments, as to the comparative dignity of Conifers, and see that they are certainly not inferior to a host of other Phænogams, some of the highest of which have fruit of the very simplest kind, though we may recognise very curious resemblances, and though we may admit that these are decided analogies, we shall not be prepared to ascribe any close affinity between them.

51. The various theories which have been mooted from time to time respecting spontaneous or equivocal generation, have been, for the most part, grounded on the development of Cryptogams, and of those animals which are lowest in the scale of creation. Such fancies, however, have by no means been confined to them, for no less remarkable phænomena occur occasionally among Phænogams, a few of which may be mentioned. It is, for instance, a well-known fact that on our eastern coast, when land is taken in from the sea by means of embankments, and the tide finally excluded, the first vegetation which appears is a crop of white clover. When heath is burned in many districts the same plant makes its appearance. *Sisymbrium Irio* covered every ruin after the Great Fire of London in 1666, and in many parts of the United States the certain follower of extensive conflagrations in the forests is *Lactuca elongata*, which, in consequence, is known by the name of fire-weed. Now it would be quite as rational to suppose spontaneous generation in these cases as in those of Fungi, the lower Algæ, or Mosses. The woods in my own neighbourhood are sometimes blue with Columbines the year after the underwood is cut, though it may be difficult to find a plant at other times; and it is notorious that certain Orchids, as *Ophrys apifera*, *Epipactis latifolia*, &c., appear only periodically in situations which are sometimes quite naked, sometimes covered with Brushwood.* But in these

* Some of the Orchids produce bulbs which are many years before

instances the overwhelming shade is quite sufficient explanation of the dormant seeds and tubers, and the other cases would admit probably of as easy a solution, were they studied on the spot. Now as regards Fungi and the lower Algæ, it cannot be denied that their appearance is often puzzling enough, but as much of the mystery which was formerly attached to the phenomena exhibited by intestinal worms has vanished under the investigations of Steinstrupp, Siebold, Van Beneden,† &c., I doubt not that those facts which still appear so perplexing, will admit some day of easy explanation. Wherever proper pains have been taken to exclude every possible source of error, no moulds or animalcules have ever made their appearance, without the possibility of the access of previous spores. After prolonged boiling and exclusion of the external air, as capable of conveying spores, or its admission only after first traversing some fluid, as sulphuric acid, which is destructive of life both in the animal and vegetable world, and therefore would char any spore that the air might contain, not a living molecule has ever originated in any organic substance or fluid charged with organic matter. And the same may be said of reputed metamorphoses of Algæ into Fungi, and the contrary; both notions rest either on imperfect observations, incomplete

they come to maturity. A recent memoir of Fabre, in Annales des Sc. Nat., relative to the development of the tubers in *Orchis hircina*, may suggest some hints on this subject. Ann. d. Sc. Nat. Sér. 4, vol. 4.

† I allude more especially to the origin of flukes, tapeworms, &c., from minute creatures nursed in the bodies of other animals. The connection between the *Cystocercus* of the pig and *Tænia Solium* the common human tapeworm; that of cysts in the heads of sheep and the tapeworm of the dog; a parasite of *Lymnæa* and the sheep fluke, are now established beyond doubt, and these are not the only examples. It would be curious to ascertain of what worm the sorices of the human liver are the infant condition. That the animals hatched from the ova of the tapeworm should be able, notwithstanding the powerful jaws with which they are furnished, to travel, in spite of all impediments, as far as the brain, even though it be by penetrating the blood vessels, is perfectly astonishing. It is easier to estimate the progress of such species as are nursed in the liver, by way of the hepatic duct.

knowledge of the objects themselves, or confusion respecting the proper limits which separate the animal and the vegetable world. They were, a few years since, almost universal in Germany, and were received with favour by a few French Botanists, but have never gained much ground amongst ourselves, except in popular belief. In France and England at the present time they are all but exploded, and I am happy to see that German botanists are beginning to follow in the same direction. Some, however, still lean to the old notion, as, for example, Dr. Cohn, in a late article on the mould which is so fatal to flies in autumn, and which he supposes to arise by a free development of vegetable cells in the diseased blood.* With respect to parasitic Fungi, which have been regarded either as mere metamorphoses of the parent cells, or as spontaneously generated, it must be borne in mind that one species at least, *Tilletia Caries* (the common Wheat Bunt), may be propagated by the spores at will. The infected plants are at once distinguishable from those which have had no contact with the parasite; and, though not the slightest trace of fungal threads can be found in them, it is quite certain that something capable of reproducing the species is present, either in the intercellular passages or protoplasm. This is applicable to hosts of fungi of very different affinities which protrude through the tissues of decaying branches. In the case of *Botrytis infestans*, the fungus which is, in my opinion, the proximate cause of the potato murrain, the walls of the cavities of the carpels of Tomatoes are often covered with the fungus, though there is no communication with the outward air; and a crop of the mould has been seen to grow in a few hours from the cut surface of a diseased potato, even though the foliage itself had exhibited no traces of the parasite.

52. Were spontaneous generation true, and plants produced

* Hedwigia, 1855, p. 59. His words are, "The influence of the spores of *Empusa* in the appearance of this fungus, and of the disease in flies, is by no means evident, since the genesis, the chemical and optical characters of the numberless free cells in the blood, the absence of a special expanded mycelium, and above all the whole history of the development, seem to concur in favour of the origination of the cells of the *Empusa* from the diseased blood."

like chemical substances from inorganic matter, according to definite laws, the species would, in all probability, admit of far more accurate definition : at any rate the species of Cryptogams in general are not more certain than those of Phænogams. Some, however, maintain, on the contrary, that there can be no certain species of Cryptogams on this account. There are, however, in no part of Botany more certain species than those of the higher *Hymenomycetes* when properly understood, especially, as Fries remarks, in the genus *Cortinarius.*

53. Cryptogams, then, as a distinct class of organised beings, and from various considerations connected with them, form a very important object of investigation. They are, for the most part, the first objects which clothe naked rocks when they emerge from the bosom of the sea, and they afford the last indication of vegetable forms under degrees of heat and cold which are fatal to other members of the same kingdom. Stones of the closest texture, if there is a proper degree of moisture, even under the direct rays of the sun, soon exhibit traces of Cryptogams, and in hot springs, at temperatures which seem almost fabulous, certain species will flourish ; while the depths of the Arctic and Antarctic Seas and the brashy pancake ice are equally productive. There is, moreover, a singular variety in the nature of these bodies, so that there is scarce a part of the surface of the globe where they may not be found. Both fresh and salt water, within certain limits as to depth, and temperature, teem with them ; arid plains, turfy peat-mosses, the recesses of woods, the deepest mines, the surface even of icebergs, and, if it be not a mere fancy of Ehrenberg's, the bowels of the earth and the regions of air are not exempt; and then not only are there multitudes of forms amongst them of excessive minuteness, but some of the noblest objects in nature, as the tree ferns, belong to the same class. They are often the pests of man, spoiling his provisions, and interfering with the operations of art. Neither are living organisms exempt. True parasitism exists in Cryptogams, which, in consequence, give rise to a host of diseases, especially in the farm and garden, and wherever vitality is very low, certain species are capable of establishing themselves on exposed surfaces

even in the animal kingdom; nay, they grow occasionally within cavities perfectly cut off, as it should seem, from the outward air, or where the structure of the tissues is so close as scarcely to admit of the penetration of any save fluid matter. The species meanwhile have a far greater geographical extent than plants in general; similar climates constantly afford similar species, though with different species intermixed, of which many are altogether local. In every country they constitute an important element in the number of species; and in some, as in Sweden, they are four or five times as many in number as the Phænogams, while in South Shetland, there is but a single Phænogam, and in Cockburn Island, the nineteen species which form its Flora are all Cryptogams. In the tropics, generally, this proportion decreases, but where there is moisture enough even there the ferns often constitute a striking, if not a predominant, portion of the Flora. But not only do Cryptogams prevail frequently to a very great extent in number of species, but in number of individuals also. The myriads of acres covered with reindeer moss in the North of Europe and Asia, produce a number of individual plants of the same species far exceeding anything that can be compared in that respect amongst Phænogams. In our own country, *Pteris aquilina* often excludes almost every other vegetation.

54. The degree in which some Cryptogams are capable of resisting long-continued drought, is most remarkable, though growing on rocks exposed to a burning sun; witness the Lichens, whether crustaceous or foliaceous, which revive with the first shower as perfectly as a dormouse waking from its winter's sleep, and the same applies to many mosses. And this, be it observed, is totally different from the case of bulbs, which grow in plains which, during a portion of the year, are arid deserts, and burst forth with the first appearance of the periodic rains; for, in the one case, the whole plant is exposed, and in the other, a body which performs the functions of a seed, the centre of which is protected by the surrounding envelopes from the drying action of the air; while many bulbs have the additional protection of a greater or less depth of soil. In these cases, it may be observed that the cells are laden with starch or bassorine;

and many of those Cryptogams which are most capable of enduring drought, as Lichens, are precisely those into whose composition a larger proportion of amylaceous matter enters. The spores, too, of some, as of certain species of moulds, are capable of resisting the temperature of boiling water, a fact which would be almost incredible, were it not confirmed by repeated observation. It is true that some seeds of Phænogams may be immersed in boiling water without losing their power of germination, but these are seeds with thick integuments, through which the heat does not penetrate with sufficient rapidity to make a short immersion fatal. I have, myself, recorded an instance of the germination of thousands of grape seeds after three immersions in boiling water; and Dr. Lindley mentions the curious fact of raspberry seeds growing after being boiled for jam, in which case, if the sugar were really boiling, the temperature would be above the boiling point of water. It is manifest that in neither case were the observations sufficiently exact, as, indeed, too often happens where they are not founded on direct experiment.

55. Cryptogamic plants are divided naturally into two great classes, viz., those which approximate more nearly, by reason of their foliaceous appendages and green tint, passing into shades of red or purple, to Phænogams, and which exhibit something more or less remotely resembling the formation of the embryo in Phænogams, as Ferns, Mosses, Liverworts, &c.; and those which are leafless, very rarely of a vegetable green, and whose fructification consists either of cells separated from the tip of certain privileged filaments, or formed within their cavity from the protoplasm, which are at once fertile, without any approach to the production of an embryo. The latter, as more simple, will claim attention first. Indeed, the differences between these two great divisions are so prominent, that the doubt, perhaps, is whether they should be associated under one name, for they are as distinct from each other, as the former are from Phænogams, to many of whose attributes they approach in Clubmosses, and *Marsileaceæ*. Many names have been proposed, to distinguish them, and of these, as the least liable to objection, I shall take those of Acrogens and Thallogens, proposed by Lindley, in the Vegetable kingdom, which are, in

fact, more or less closely, those of Endlicher and Brongniart. The former, then, will be designated as Acrogens, without, however, supposing too strictly that new matter is deposited only at the extremity, and the latter as Thallogens (plants in which there is a fusion of root stems and leaves into one general mass) which is equivalent with that of *Amphigenæ*, of Brongniart. When these two grand divisions are established, we shall be enabled to form a much more clear and precise notion of the objects under consideration. There is no difficulty, for instance, in framing some general conception which shall embrace, in the same bird's-eye view, the smallest moss and the most gigantic tree fern, while nothing but a complete ignorance even of the outward characters of the fruit will confound in the same class, the most frondose Lichen or Alga, with the least frondose *Jungermannia*.

56. The word Acrogens, as observed before, has been applied to the whole race of Cryptogams. There is no question about its more general application now. Though very insufficient in the first instance, it may be proper enough when used in a restricted sense. In the sequel, I purpose to give such tabular formulæ as may assist the student in taking a general view of the subject, and of obtaining some insight into the divisions into which Cryptogams are naturally divisible, but it will be well, as we proceed, to contrast the prominent distinctions of parallel groups. Cryptogams, then, in the first instance, are divisible into two great groups:

CRYPTOGAMS.	THALLOGENS.—	Seldom herbaceous or provided with foliaceous appendages; foliaceous appendages, if present, destitute of stomata. Spores rarely producing a prothallus; and, if so, giving rise to a second order of spores, germinating at definite points. Spermatozoids not spiral.*
	ACROGENS.—	Mostly herbaceous, and provided with distinct, often stomatiferous foliaceous appendages. Spores, for the most part, producing a prothallus, or if not, complicated fruit by means of the impregnation of an embryonic cell. Spermatozoids spiral.†

* Itzigsohn, however, asserts that spiral Spermatozoids exist in *Spirogyra arcta* and *Cladosporium*. Hedwigia, 1852, 1855.

† It is to be observed that those Thallogens which have the green

tint of Phænogams, are generally very simple in their structure, and of these the species which are most fruticose in habit, as *Caulerpa*, consist of a single cell, however large and complicated the plant may be. In some of the finer Algæ alone, organs exist, comparable with leaves for their nervation and expansion. The prothallus, when produced, ends in the formation of spores, analogous with pollen grains, and with the spores of Acrogens, and homologous with the sporophores of Hymenomycetous Fungi. The embryo cell in the more typical Acrogens gives rise to an analogue of the embryo in Phænogams, but in the less typical, in which there is no prothallus, to fruit analogous with stamens. The produce of the spores, though themselves generated after the same type, is so different, that all comparisons are attended with great difficulties.

CLASS I.—THALLOGENS. *Lindley.*

CRYPTOPHYTA, *Lk.*—ANANDRÆ, *Lk.*—APHYLLÆ, *D.C.*, *Lindl.*—*HOMONEMEÆ, *Bartling*, *Fries.*—HOMOROANA SPORIFERA, *Schultz.*—THALLOPHYTA, *Endlicher.*—PROTOPHYTA, *Perleb.*—AMPHIGENÆ, *Brongn.*—ACOTYLEDONEÆ, *Ag.*

CELLULAR, rarely herbaceous, plants for the most part destitute of a distinct stem with foliaceous appendages, which, if present, are void of stomata ; fruit either naked, or in the form of distinct organisms, which produce spores at the tips of certain privileged filaments, or sporidia from the organization of their endochromes ; more rarely arising from the mere subdivision of the component cells. Spores very rarely producing a prothallus, and if so, giving rise to a second order of spores, which germinate at definite points. Spermatozoids, very rarely, if ever, spiral, furnished with flagelliform processes, or destitute of such processes, and resembling ordinary spores; in some cases merely represented possibly by minute deciduous sporiform cells. As before, the several names which have been applied will nearly give the characters :

1. *Cellularia, Homonemeæ, Homorgana.*
2. *Aphyllæ, Thallophyta, Amphigenæ.*
3. *Acotyledoneæ.*

57. It is, perhaps, impossible to comprise within the limits of a few words, a satisfactory definition of productions, which differ so greatly in character and general appearance, as the extreme

* There is certainly a distinction of root and stem in many, even of the simplest Thallogens. The root in Algæ is often a mere holdfast, but in other cases it penetrates into the soil, and absorbs nutriment, and the same may be said of some of the simpler Fungi. In the higher Fungi, this opposition is still more evident.

forms which claim a place in this grand class. If the simplest cellular algæ, as for example, *Scenedesmus obliquus* (Fig. 16, *a*),

Fig 16.

a. Scenedesmus obliquus, Kütz, magnified from specimens gathered at King's Cliffe.

b. Lessonia fuscescens, Bory., reduced from Dr. Hooker's figure in Flora Antarctica.

be compared with *Lessonia* (Fig. 16, *b*), or *Macrocystis;* a *Gymnosporium* (Fig. 17, *a*), with an Agaric or *Cordyceps* (Fig. 17, *b*); or finally the Leprarioid *Sporidesmium* (Fig. 18, *a*) with a *Cenomyce* (Fig. 18, *b*), for there are no perfect Lichens which will not come under one general type of fructification, we shall at once see that it can only be by straining words beyond

Fig. 17.

a. Spores of *Gymnosporium fulvum*, Berk., magnified from specimens received from Mr. Lea.

b. Cordyceps Sinclairii, Berk. in Fl. of New Zeal., p. 338, from specimens communicated by Mr. Gourlie.

their proper meaning, that a technical character can be framed which shall comprise all. And more especially when we reflect, that many of the lower Algæ consist apparently of a succession of divisions of a few primeval cells, without any distinct thallus, however obscure ; that others are mere ramifications, or prolongations of a single thread; while others, again, are almost as complicated as higher Cryptogams, and approach them in the development of a distinct stem with foliaceous appendages, and these frequently furnished with nerves and veins, so as to simulate those of higher plants. Simple as the lower types are, we should be much deceived if we supposed that the same simplicity pervaded the whole class. A glance at the figures of Tulasne and Kützing, representative of Truffles and the larger Algæ, will be sufficient to dispel such a notion. The dignity of these bodies is in truth not to be measured by the more ignoble species, some of which, however, on examination, prove far less simple than was once supposed. If there were any truth in the notion, that a slimy matter is produced in damp places, under certain chemical conditions, which gradually becomes organised, and then contains

Fig. 18.

a. Sporidesmium Lepraria, Berk., magnified from a specimen communicated by Mr. Borrer.

b. Cladonia cornucopioides, Schær. Moug. No. 752, nat. size.

c. Roccella fuciformis, D. C. var. from Valparaiso, nat. size.

granules, which, according to the predominance of certain phenomena of temperature, light, electricity, &c., give rise indifferently to Algæ, Fungi, or Lichens, there would be no difficulty in admitting the vulgar notion, that *Polyporus squamosus* is a mere product of the sap of the tree on which it grows, or even that plants and animals, however complicated, may spring from decomposed or decomposing organic matter; especially if the notion be extended still farther, as it is by many German authors, so as to include the possibility of this same protoplasm (urschleim) being equally capable of giving rise to the lower animals. The ground, however, is fast sliding from beneath the feet of such philosophers; organisms which once were supposed to be so simple, are found to be, in fact, somewhat complicated; the presumed distinctions of animal and vegetable life are not so certain as was imagined by older physiologists; and in consequence, when a *Protococcus* (Fig. 8, 9), in one stage of growth produces veritable spores, and in another bodies endowed with apparently voluntary motion, by means of flagelliform appendages, we are not at once to presume that such effects take place indifferently, but should conclude, rather, that they are bound up in the very nature of the production, and that the two kinds of bodies are no more organisms generically or specifically distinct from the parent, than the male offspring is from the female in the animal kingdom.

58. Thallogens consist, in most cases, of cells, modified in form, and in the nature and chemical condition of their walls, but never accompanied by spiral tissue, except in the organs of fructification, where its office seems to be principally the gradual dispersion of the reproductive bodies. Whatever aëration may take place in their substance, it is at least not conducted by spiral vessels or by analogous ducts, but by large intercellular passages, or the void space between the component filaments, where the cells, as is very frequently the case, are drawn out into threads. They are entirely destitute of true stomates, though in many cases, from their spongy nature, the air has free access into their substance. In many, however, the inner cells must be cut off from communication with the atmosphere, except by endosmose, and in the aquatic species, external apertures are scarcely to be expected. *Cladonia retipora* (Fig. 19) presents a frond remarkable for its perforation, and some other Lichens in

a less degree. In most species of Lichen, the outer walls are densely compacted and cartilaginous, so as to present some difficulty of penetration in that direction, except from accidental fissures or normal ruptures, while the spongy base more readily

Fig. 19.

a. Cladonia retipora, Flörke, nat. size.

b. Portion of stem magnified to shew the porous structure. From an Australian specimen given to me by Sir W. J. Hooker.

absorbs moisture. Though even in the largest *Algæ* there is no wood, properly speaking, still the stems sometimes acquire considerable dimensions, and even shew concentric zones (Fig. 15), which arise, probably, from distinct periods of growth and rest, as in *Dasycladus clavæformis,* and in those *Polypori* whose flesh exhibits similar markings.

59. A second mark of distinction is, that they have no true leaves. As was before stated, they have foliaceous expansions of various kinds and forms, resembling, in some cases, true leaves very closely, and in some degree, perhaps, performing their functions, at least, so far as exposing a larger surface to the light, and the medium in which they grow, and from which they derive their nutriment. The processes of absorption, nutriment and aëration are frequently, however, in these plants, altogether confused, the seeming roots being little more than grappling threads, intended to fasten them in their proper place, and enable them to withstand the force of wind and waves. In some cases, indeed, amongst Algæ and Lichens, and very generally among Fungi, the rootlets may

imbibe nutritious matter from the soil or matrix, but this is very far from being a universal attribute. When fronds are present, they are seldom disposed symmetrically, except they take the form of threads; in which case they exhibit, at times, the most exquisite arrangement, so as to make them objects of much admiration, and some of the most symmetrical occur amongst species of inferior dignity. The symmetrical arrangement of the subulate processes in *Chara*, does not come under the present head; for the nature and mode of origination of the spermatozoids associates these plants evidently in the second great class of Acrogens.

60. A third common character is afforded by the nature of the fruit. In a few simple cases the process of fructification consists merely in the division of the mother cell; but, in general, the reproductive bodies are due to the thickened end of certain of the component threads, which ultimately separates and forms sometimes a single spore, consisting of a double cell wall with its endochrome, or of a multitude of endochromes produced by division of the cell; in other cases, however, the endochrome of the cell itself (which is then called an ascus), becomes organised without any change of the inner membrane, and presents a definite or indefinite number of distinct reproductive bodies. In many instances, both the spore-bearing threads and asci are naked; but very often, they are either permanently contained as a lining in distinct organisms, or at length exposed to the open air; sometimes, they form a tuft, springing from the base of the fructifying cavity, after the fashion of a central placenta.

61. Another distinctive feature consists in their various modes of fructification, in the same individual species. This has long been notorious in the case of the more important Algæ, and it is daily becoming more evident amongst Fungi, and will, probably, be extended to the whole group. It is difficult at present, in the absence of direct observations, to say precisely what is fruit and what is not, as it appears that in many cases the secondary form may be representative of male organs, if not functionally such. Certain it is, at least from the observations of Thuret, that the spermatozoids of Fuci, which our countryman,

Carmichael, was the first to discover, do really perform the office of fecundation. Amongst Fungi, in many cases, the secondary form germinates equally with the primary, but then there is sometimes added a third, or even a fourth or fifth.* (Fig. 20). Where there are true spermatozoids, there is often more than one form of reproductive granules, though both, possibly, may not receive impregnation.

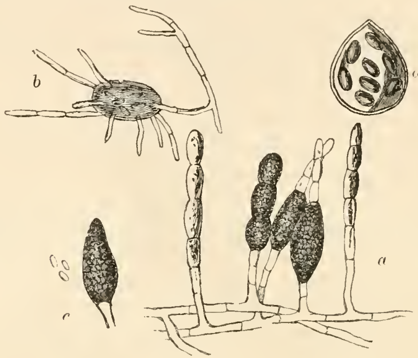

Fig. 20.

Sphærotheca Castagnei, Lév.

a. Threads of mycelium, with some of the joints turned into pycnidia.

b. Granules germinating within ordinary moniliform cells.

c. Pycnidium and its contained stylospores.

d. Ascus, with sporidia. Berk. in Tr. of Hort. Soc., vol. ix. p. 68.

62. The question now arises, into what principal groups are these bodies naturally divisible. Now, though the matter is not without exception, it must at once strike any one who observes them collectively, that certain differences exist, order-

* In *Erysiphe*, there are no less than five different forms of fruit; the moniliform threads on the mycelium; the asci in the sporangia; the larger stylospores in other sporangia; the smaller stylospores in the pycnidia; and the separate sporules sometimes formed in the joints of the necklaces.

ing them into three very natural groups, according as they inhabit the water, the earth, or the air. The great tribes of *Confervæ* and seaweeds, for instance, with very few exceptions, are entirely or periodically submerged, and live at the expense of matter imbibed from the medium in which they grow. The Lichens, though with more numerous exceptions, grow on bodies from which they can derive no nutriment, but depend upon supplies which come from the surrounding air, the exceptions of aquatic species being very few indeed; while, on the contrary, the Fungi are altogether dependent upon their matrix, are frequently parasitic, and are not unfrequently confined to a single species, genus, or natural order of Phænogams. The aquatic species are as rare as in Lichens, and more so than the truly terrestrial among Algæ. That the three groups are natural, it is quite impossible to deny. The question is, whether they are groups of precisely the same importance; a question, the difficulty of which has been felt by most authors who have treated on the subject. Linnæus, for instance, and Jussieu, considered Lichens as forming a part of Algæ, in which they are followed by Fries, one of the best authorities upon Cryptogams, and, above all Botanists, possessed of that tact which grasps the real affinities of organisms, even before their structure is accurately known. It is true that two of the groups are easily and naturally divisible into more, but the question is not as to subordinate groups, but as to the larger and more comprehensive divisions. The real difficulty, indeed, lies with the Lichens; but this is far less than it was formerly, since it has been proved that, in essential structure, and in their secondary fruit, whether of sexual importance or not, they are most closely related to Fungi. For my own part, I am of opinion, that at any rate the nearest alliance of Lichens is not with Algæ, but with Fungi; there is not a single instance amongst Algæ, of ascophorous fruit, for such genera as *Lichina*, *Mastodia*, &c. are evidently allied to *Collema*, and, though the thallus of *Collema* is nearly identical in structure with *Nostoc* or *Hormosiphon* (Fig. 21), I consider this merely an osculating point; the true mode of increase in *Nostoc*, which is now well known, connecting that genus rather with *Palmelleæ*, than with higher forms. It is possibly, after all, a mere matter of analogy, though some will insist that true species of *Nostoc* are capable of being developed into Lichens.

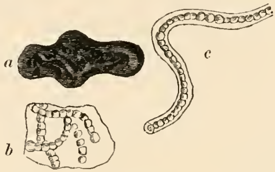

Fig. 21.

Hormosiphon arcticus, Berk.

a. Plant, natural size.
b. Portion of do., magnified.
c. Thread of spores, with its gelatinous envelope.
From a specimen gathered near Beechy Island, by Dr. Sutherland.

63. A point, however, of considerable importance is this: that, both in Algæ and Fungi, there is a complete series of forms from beings of extreme simplicity of structure, consisting of merely one or two cells from which more complicated organisms gradually diverge, ending in the most perfect Seaweeds and Fungi; while in Lichens, the very simplest display perfect fruit, resembling altogether that of Fungi, insomuch that, of many species belonging to either group, it is almost impossible, in the absence of crust, to say whether we have a Lichen or a Fungus before us. It seems, therefore, far preferable, to regard Lichens as forming a great group, co-ordinate with Fungi, but of an inferior dignity to the parent group, or to Algæ. The only acute difference that can be pointed out between Fungi and Lichens, is the presence of green bodies, called gonidia, in the latter (reproductive bodies produced from the tips of certain internal threads), and this even ceases in some of the more obscure *Verrucariæ*, and in epiphyllous species. It is impossible, in fact, to point out any real difference between *Asterina*, and such species of *Strigula* as *S. Babingtonii*, and it must be remembered, that Fungi, with a similar habit, take their first growth, like *Strigula*, beneath the true

cuticle, as *Asteroma Rosæ*. It is true, our difficulties of definition have increased; and if Lichens are to be considered as of equal dignity with Fungi, both belonging to one large group, there is a necessity for giving that group a distinctive name. In such matters, systematic effect, or neatness of character, is not to be studied, but the real affinities of plants; and if a closely allied group be separated too acutely, the affinities will sometimes vanish from the view. I shall therefore, at all risks, consider Algals, or Hydrophytes, as forming the first grand group; and for the second, propose the name of Mycetals, comprising the two received alliances of Fungals and Lichens.

The Thallogens will then stand thus:

A. ALGALES. Cellular flowerless plants, for the most part without any proper roots or mycelium, living, with rare exceptions, entirely in water, and imbibing nutriment by their whole surface, from the medium in which they grow.

B. MYCETALES. Cellular flowerless plants, at first, furnished with a mycelium, very rarely immersed, deriving nutriment from the matrix, or from the surrounding air.

a. Fungales. Hysterophytal or Epiphytal Mycetals, deriving nutriment, by means of a mycelium, from the matrix, never producing from their component threads, green bodies resembling chlorophyll (gonidia).

b. Lichenales. Aërial Mycetals, deriving, for the most part, nutriment from the surrounding media; producing, from the component threads of their thallus, abundant gonidia.

THALLOGENS.	ALGALES.	Deriving nutriment from the water in which they are submerged.		
	MYCETALES.	Deriving nutriment from the matrix, or the surrounding air; mycelium more or less evident.	*Fungales.*	Hysterophytal or Epiphytal; nourished by the matrix, never producing gonidia.
			Lichenales.	Aërial; nourished by air and not by the matrix, producing gonidia.

64. Fries has long since pointed out that there is no certain distinction between Lichens and Fungi, except the presence in the former of green globules, resembling grains of chlorophyll. Such distinctions are not without real importance. If *Vaucheria* (Fig. 22), and one of the parasitic species of

Fig. 22.
Vaucheria submarina.

Magnified. From specimens gathered at Weymouth.

Botrytis, such as *B. parasitica* (Fig. 23), be compared together,

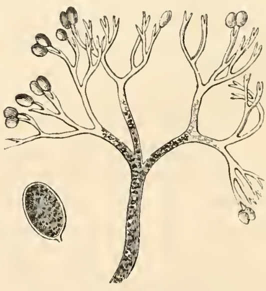

Fig. 23.
Botrytis parasitica, P.

With spore, more or less magnified, from specimen gathered at King's Cliffe.

I know of no external distinction,* except their place of growth and difference of colour. The definitions of the three groups, as given by Agardh and Brongniart, will not hold good in numberless instances. The definitions given above, will, at least, point out the main distinctions; but it is probable that the rooting threads of *Botrydium* (Fig. 24), *Caulerpa*, and of many of the calcareous Algæ, do absorb nutriment from

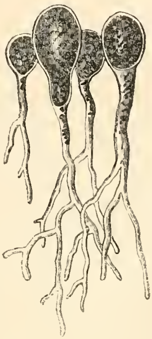

Fig. 24.

Botrydium Granulatum, magnified.

the soil, and, perhaps, for the reason that they are frequently exposed to the dry air, and would, therefore, wither without such a provision, or are so incrusted with lime as to render nutriment through the surface precarious. It can scarcely be supposed that Lichens never derive any nourishment from their matrix, because certain species grow only upon certain kinds of rock, and some burrow into the matrix; still, even in these cases, it is clear that the principal part of their nutriment is not imbibed by the spongy tufts, or scattered filaments on the under side of the thallus.

* There are, indeed, recondite differences, as will appear hereafter, some of which have only lately been ascertained.

ALLIANCE I.

ALGALES, *Lindl.*

ALGÆ, *Juss. D. C., Agardh, &c.*—THALASSIOPHYTA, *Lam.*—HYDROPHYTA, *Lyngb.*— HYDRONEMATEÆ, *Nees.* — HYDROPHYCÆ, *Fries.* — PHYCÉES, *Montagne.*

CELLULAR flowerless plants, without any proper root or mycelium, living, for the most part, entirely under water, and imbibing nutriment by their whole surface, from the medium in which they grow. Propagation of various kinds, sometimes by the mere division of the endochrome, sometimes by spores or zoospores, formed from the endochrome, or by the mixing of two endochromes; sometimes by the joints of privileged threads, either naked, or contained in especial organs, and occasionally of two orders. Sexes often distinct on the same or different individuals; impregnation, by means of spermatozoids furnished with one or more flagelliform appendages, but obsolete in the lower species; spermatozoids very rarely, if ever, spiral.

65. The objects which constitute this large family, are extremely variable in appearance. Many can scarcely be examined as regards their external characters, without the assistance of a magnifying glass; while others form subaqueous forests, or float in dense masses many miles across, the individual plants of which are sometimes one hundred feet or more in length; some are devoid of all beauty, while others are, perhaps, the most elegant objects in nature, alike attractive in form and colouring; added to which, the markings in the siliceous shells of one main division are so exquisite, as to constitute them the most admirable objects for the microscope.

66. The first question which occurs in the consideration of the subject generally, is where the limits of the order are to be sought. It is very clear, that many of the lower species are upon the very confines of the animal kingdom, and in consequence, many undoubted Algæ have been referred by authors to that division of organised beings. There was, indeed, some

excuse for the earlier observers, if they made mistakes, and preconception easily gave rise, under the imperfect magnifiers, some twenty-five years since, to reports of structure which had their existence only in the imagination of the writers. When Dujardin had once called in question, and with great propriety, many of Ehrenberg's observations, with regard to undoubted animalcules, there was not much hazard in doing the same with respect to *Diatomaceæ* and *Desmidiaceæ* (Fig. 7). A practised observer, with good modern instruments, would now scarcely entertain a doubt upon the subject, when such objects as the eggs of *Aplysia* and Gnats (Fig. 12), not to mention such Polypidoms as *Alcyonidium*, are placed before his eyes, though they, and many similar productions, were formerly registered as vegetables. It is true, that in some cases, motion may exist, and that apparently, voluntary; but it is now well known that such motion is by no means a certain indication that a given body does not belong to vegetables. In the article *Vaucheria clavata*, of the Gleanings of British Algæ, so long ago as 1833, I drew attention to the possibility of animal and vegetable life existing at different stages of growth in the same individual, and what is stated there, requires but little modification now, even after the discoveries which have since been made respecting zoospores and spermatozoids. It is precisely at such osculating points that these complex phænomena may be expected; and as life, whether animal or vegetable, is only a phrase, formed to express certain phænomena, the plain fact is, that similar phænomena are exhibited by animals and vegetables, though such phænomena may be confined to a very small period, compared with the whole range of existence. The degree of volition, if such it may be called, is extremely low, and may be unattended with any consciousness, and merely be the indication of certain exigencies of the minute body for light, or other necessary elemental conditions. When, however, it is said by the German naturalists, that organised matter has a tendency to be converted into organised bodies, a proof is required on the part of the assertors, that every source or possibility of error has been removed, before they can challenge even a state of philosophic doubt. A careful examination of Kützing's papers, in Linnæa, vol. 8, 1833, and much more of his prize essay, will show a multitude of such loopholes; and, but for his acquaintance with species, they never would have commanded so much attention as they have; and if Kützing's observations are suspicious, still more assuredly those of Reissek, who professes to have witnessed the transformation of chlorophyll into Algæ, and pollen grains giving rise to moulds laden with spores, which spores, when placed in water, produced Confervoid plants filled with chlorophyll, and copulating with one another. Nay, more than this, he reports the metamorphosis of pollen cells into animals, belonging to Ehrenberg's genus *Astasia*, and that the contents of the pollen cells also produced plants and animals. From the smaller particles, originated *Bacteriæ*, *Vibrios*, and *Confervæ*, from the larger green globular monads.* While we doubt not the fact of his obtaining the germination of pollen grains apart from the stigmatic moisture, as in the parenchym of plants, sometimes belonging even to a different natural order, a fact which has no unimportant bearing on some physiological questions, respecting the impregnation of the ovules of Phænogams, under certain anomalous conditions, it cannot be allowed for a moment, with every deference to the fidelity of the author, that his investigations were conducted in such a way as to challenge belief. I shall, on this subject, beg leave to reproduce the passage from the Annals of Nat. Hist., v. xiv. p. 434, which has been quoted by Dr. Lindley, in the Vegetable Kingdom, because I cannot express my sentiments better than I did there.† "As far as I understand what I have read upon the subject, I cannot help remarking first, that the observations cannot be considered conclusive, apart from all

* This is from a mere verbal report by Reissek, in Bot. Zeit. July 19, 1844; but a full account with figures has since been published.

† The passage is in a review of Kützing's Treatise, Ueber die Verwandlung der Infusorien in niedere Algen-Formen. Nordhausen, 1844, with an especial view, at the same time, to his larger Prize Treatise, Die Umwandlung niederer Algen-Formen in höhere so wie auch in Gattungen ganz verschiedener Familien und Klassen höherer Cryptogamen mit Zelligem Bau. Haarlem, 1841.

prejudice either way, till a certain number of bodies, ascertained to be precisely of the same nature, be isolated, and the changes of these observed, with every possible precaution, to avoid error. At present, it seems to me that there is not by any means sufficient proof that the objects in question really arise from germs of the same nature. The second remark I would make is, that there appears, too often in treatises of this description, to be great indistinctness as to the notion of what a species really is. We know that in the course of development, higher bodies go through a vast variety of phases, which resemble closely true substantial species which have arrived at their full development, but we are not therefore to suppose that in passing through these phases the production has really consisted of such a number of real species. In the Agardhian sense this may be true enough, for when he pronounces the vessels and cells of phænogamous plants to be Algæ, his reasoning appears to be, however strongly he expresses himself, merely that they are representatives of Algæ, and resemble them in structure. I would remark, also, that the real difficulty of the case does not depend on the question as to the difference of animal and vegetable life. These evidently in certain parts of the creation are so intimately combined, that it is quite impossible to say where the one ceases, and the other begins; and there is really no reason why we should be incredulous as to the possibility of the same object being at one time endowed more especially with animal, and at another with vegetable life. Late observations on the reproductive bodies of some Algæ show that their motion is produced by vibratile cilia, exactly in the same way as in certain animals. But it is exceedingly difficult to imagine the transformation of one real species into another. The same species may assume a vast variety of forms, according to varying circumstances, and it is highly instructive to observe these changes; but that the same spore should, under different circumstances, be capable of producing beings of an almost entirely different nature, each capable of reproducing its species, is a matter which ought not to be admitted generally without the strictest proof. Observations made with care on isolated individuals, and not on a common mass, which can scarcely be otherwise than more or less heterogeneous, could not fail to be instructive; and might lead to results which, if they did not confirm the views so commonly entertained in Germany, would have an influence on science which it is difficult at present to appreciate."

67. For a long time, motion, as said above, especially if it had the semblance of being voluntary, was esteemed a certain mark of discrimination between the animal and vegetable kingdoms. Mere molecular motion, or that due to evaporation on the field of the microscope, was therefore often brought forward as an argument for the exclusion of many vegetables from their proper position in the organised world. And there is the same disposition occasionally now.* To take the example alluded to before of *Ulothrix* (p. 18), and there are many similar examples, as *Conferva glomerata*, *Achlya prolifera*, &c., the articulations give rise, from their protoplasm, to cells terminated by delicate cilia, by means of which, they move about apparently at will, till the appendages lose their activity, and the body sinks, becomes fixed at one end, and at the other produces a new individual precisely like that from which it originally sprang. Sometimes, as in *Stilophora rhizodes*,† there are two distinct formations of such bodies, from distinct parts of the plant, both of them equally endowed with motion, and both equally capable of reproducing a plant like the original, though not precisely by the same series of phenomena. These bodies are, moreover, so like certain Infusoria, as *Diselmis*, Dujard., that without ascertaining the changes which take place during the course of their existence, it would be

* See a notice of the motions of *Navicula Vichiensis*, Petit, by M. Petit, in Montagne's Sylloge Gen. et Spec. Crypt., p. 471.

† Thuret, Recherches sur les Zoospores des Algues, Partie 1, tab. 28. In other cases, doubtless, two kinds of Zoospores are produced, as in *Leathesia* and *Mesoglœa*, as they have the two organs called Oosporangia and Trichosporangia by Thuret. The Zoospores of the latter are rather larger than the former. In *Cutleria*, there are bodies answering to antheridia, producing apparently Spermatozoids, but though they do not germinate, they do not seem to have the power of impregnation. They appear, in fact, to be a distinct transition from Spermatozoids to Zoospores.—*Thuret*, l. c. tab. 26, 27, 31; Partie 2, tab. 1.

impossible to assert that the two were only distantly related. We have here, then, indications of two distinct stages of existence, the first, animal, and the second, vegetable. But further experience shows us that the organism which produces these active cells, is no doubtful being, a mere Polypidom, as it were, but a real vegetable, for in other Algæ, we find two sorts of organisms, the one of which produces from its bosom ordinary spores, the other bodies precisely like the zoospores of the *Ulothrix*. We might expect, from the perfect resemblance and identity of origin of these zoospores and spermatozoids, for both arise from the protoplasm of the cells, that these also would, after moving about, subside, and reproduce the species. But this is not the fact; like spermatozoa, their activity is of short duration, and capable of being destroyed at once by iodine and other chemical bodies; when this activity has ceased without the presence of any such injurious substance, the bodies acquire no attachment, and do not grow into a thread, but gradually decay. The spores, on the other hand, make no progress, and retain their vitality but a short time if kept alone, but if the two bodies are mixed

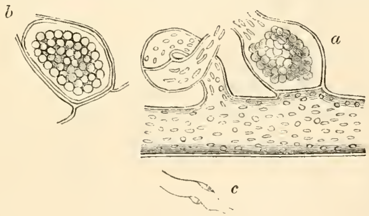

Fig. 25.

a. Portion of a thread of *Vaucheria sessilis*, Lyngb., shewing a spore cell and an antheridium. The protoplasm of the spore cell is collected towards the centre of the cell, which is filled with jelly, the apex has ruptured, as also that of the antheridium, and the spermatozoids are entering through the aperture.

b. A spore perfectly formed, which, since impregnation, has acquired a membrane.

c. Spermatozoids. All more or less magnified. From Pringsheim's memoir.

together, they soon show manifestations of vegetation, and reproduce the species. We have, therefore, spores vivified by the impregnation of bodies, corresponding in their functions with the spermatozoa of animals, and to some extent in their genesis; and the homologous bodies in the *Ulothrix* or *Conferva*, are no more proofs that these genera belong to the animal kingdom, than that *Fuci* should be excluded from vegetables, because of the animal indications of their spermatozoids.

68. Owing to this exact resemblance between the spermatozoids of higher Algæ, and the motile spores of many lower in the scale, some doubt has been conceived as to their real functions: but the direct experiments of Thuret have set such doubts at rest. In some of the simpler Algæ, however, the development of the spermatozoids, and their effect in the vivification of spores, is more easily traced than in the *Fucoideæ;* and, accordingly, we have a most valuable series of observations on *Vaucheria* (Fig. 25), by Pringsheim, to whose kindness I am indebted for the possession of his treatise.* The species principally concerned in the investigation was *Vaucheria sessilis*, an Alga consisting of a single branched and elongated cell, without any dissepiments before the formation of the fruit. Two little contiguous swellings appear on the side of the thread, one of which rapidly elongates and becomes curved, and the other meanwhile, assumes a more or less globose form. A dissepiment is then formed in the middle of the curved process, which is soon filled with minute oblong spermatozoids, furnished on one side with two filaments, by which they move. Meanwhile, a dissepiment has also formed at the base of the globose body, whose endochrome alters its appearance, a portion of the globule turned towards the male organ, swelling into a little beak; a part of the wall then gives way; the endochrome parts with some of its mucus, and a passage is left open for the entrance of the spermatozoids; the endochrome after impregnation soon acquires a membrane, and, ultimately, the whole is condensed into a spore, which

* Monatsberichte der Königl. Ak. der Wissenschaft, Berlin, 1855.

bursts through the integuments and becomes free. In *Œdogonium*, in like manner, an aperture is formed for the admission of the spermatozoids to the endochrome, which then acquires an integument, and becomes a spore, while in *Bulbochæte*, the same purpose is effected by a little fissure; the spore of the latter falls out after impregnation and then elongates, the endochrome dividing at length into four, each portion of which gives rise to a zoospore, furnished with two bundles of flagelliform cilia.

69. Both in *Œdogonium* (Fig. 26, *a*, *c*) and *Bulbochæte* (Fig. 26, *b*) little bodies* are formed on the walls of the spore cell, which seem, at first, like germinating spores. They acquire one or two dissepiments, and then discharge their contents from the ruptured apex. These, in all probability, are the antheridia. Their existence has only very lately been published, but they have been known some time to close observers. I have a sketch from Mr. Thwaites, in a letter dated April 22, 1846, which is here reproduced (Fig. 26, *a*); and I also received a mounted specimen, at the same time, in which the bodies are sometimes more numerous than in the figure. Here and there

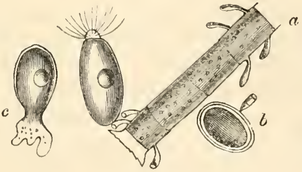

Fig. 26.

a Fertile joints of the *Œdogonium* with Antheridia, from a sketch by Mr. Thwaites, compared with a mounted specimen, April 18, 1846.
b Spore case of *Bulbochæte crassa*, Prings., with Antheridium, from a mounted specimen from Mr. Thwaites, May, 1847.
c Zoospores of *Œdogonium vesicatum*, after Thuret.

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* Thuret has evidently figured one of these, l, c., tab. 19, fig. 9, though he was not aware of its nature. These little bodies forcibly remind one of the processes produced on the spores of *Dacrymyces deliquescens*, Dub., as mentioned above, p. 44.

they are produced on other joints, as well as on those which give rise to the spores. It is curious, in two such closely allied Algæ as *Vaucheria sessilis* and *V. clavata*, to find the fruit so very different. The spore of the former is perfectly inactive, while that of the latter revolves by means of delicate cilia covering its whole surface. It is clear, then, that we must not, in these lower Cryptogams, attach too much importance to motion. Neither in these cases, nor in similar organisms in the animal world, is there the slightest reason to believe that this motion is effected by any system of muscles. Its real cause is, at present, beyond our powers of discovery.

70. Dr. Itzigsohn has figured in Hedwigia, 1852, p. 7, the spermatozoa of *Spirogyra arcta* as produced within little cells, after the fashion of those in mosses, and forming a little spiral, with a thickened extremity. Whether there is any mistake in this or not must be left to future observations; the structure in other cases, which he mentions as probable, viz., *Vaucheria*, *Œdogonium*, *Bulbochæte*, and *Cladophora*, is, where it has been ascertained, certainly very different, and resembles, more or less, that in the higher Algæ, or the bodies are not spermatozoids at all, but zoospores.

71. It is to be mentioned, moreover, in connexion with the subject, that different Algæ in different stages of growth wear so different an appearance as to seem to indicate totally different affinities. *Lemanea torulosa*, for instance, for a long time has all the appearance of a Conferva,* in which condition its nearest affinities could not so much as be suspected; the earliest stages of *Porphyra* resemble a *Bangia*, and so of other cases. This alone may lead to perplexity in such determinations, but much more the fact that it is very doubtful how far many of the supposed Algæ, such as *Glæoclapsa*, are autonomous species. Where a plant bears fruit, and is reproduced by that fruit, as for instance, *Protococcus pluvialis* (Fig. 8, 9), there can be little doubt that a species is true; but where all the propagation is a simple repetition of the division of the endochrome, as in *Glæocapsa*, there is some room for doubt. Mr. Thwaites, in the

* Linn. Tr., vol. xx. p. 399.

course of his investigations, was led to suspect that many of these lower Algæ, however beautiful and interesting as microscopical objects, were not autonomous; many seemed to pass into each other by intermediate forms, and others were so constantly the attendants of others, as *Palmellæ* of *Seirosiphon*, that he was led strongly to suspect some very close and intimate connexion; and this is formally enunciated in a late number of the *Botanische Zeitung*, Jan. 5, 1855.* M. Sachs professes to have seen a *Nostoc* generated on the surface of *Collema bulbosum*, and a *Glæocapsa* on that of *Cladonia pyxidata.*† It is to be observed, however, that he is not sure whether the *Nostoc* has arisen from the spores of the *Collema*, or from its gonidia, but he speaks positively as to the origin of a *Glæocapsa* from the threads of the lichen by the transformation of a gonidium. When the *Glæocapsa* is once formed it increases rapidly, forming a gelatinous mass, entirely distinct from the *Cladonia*. Supposing this to be true, it is not a transformation of a lichen into an Alga, but the supposed Alga is a mere condition of the lichen; and if all species of the genus belong to the same category, the genus must be erased from the system, as has been the fate of many genera once supposed to be autonomous. There is great probability in favour of such a supposition, and it will perhaps be found that most species of *Seirosiphon* are similarly circumstanced. When we come to the consideration of fungi, we shall find how many genera must eventually be expunged.

72. The total absence of vascular tissue is one of the most general characteristics of Algæ; but, as in Phænogams, the parenchymatous cells sometimes contain spiral threads, as, for instance, in the aërial roots of Orchids, or the little bulb-shaped processes which are are so common on the roots of Conifers; so also there are undoubted instances of spiral threads in Algæ. In *Zygnema*, for instance, and its allied genera, we have repeated examples, sometimes exhibiting a

* Zur Entwickelungsgeschichte des *Collema bulbosum*, Ach. von Julius Sachs.

† Mr. Thwaites found discs of cells regularly pullulating from the stem of *Lichina*, and simulating distinct Algæ.

structure almost as neat as in vessels with compound spires; though, sometimes, the principal part of the endochrome is simply collected into a single irregular band-like thread. The vascular tissue of plants in general, as observed before, is a mere modification of cellular tissue. All tissue, in fact, in an infant state, is cellular, and cell-walls, apparently simple, consist sometimes, if not always, of spirally-arranged fibres. These are visible enough in many Phænogams. In Fungi we have the same structure, in *Podaxon* (Fig. 5, *c*), and Agardh has shown that the cell-walls of some Algæ, as *Conferva melagonium* (as stated above, p. 8), have a spiral structure. The elder Agardh recognised the analogy between the woody fibres of plants and the threads of Conferva, and the analogy in point of structure is borne out as well as in more palpable attributes. We have already seen that the stems of the larger Algæ exhibit a structure somewhat similar to that of Exogens, but the resemblance does not stop here: in such genera as *Mesoglœa* there is a distinct horizontal as well as vertical system; and what is very curious, in *Batrachospermum* and some species of *Callithamnion* (Fig. 26), the thickness of the stem is increased externally by a descending system from the branches. In such Algæ, this is no merely theoretical notion, but one which a single glance at the microscope will confirm; and though the theory of Du Petit Thouars is now exploded as explanatory of the growth of Exogens, no one will deny that their growth is in direct proportion to the number of healthy buds which are developed. Kützing has figured dot-like canals (tüpfel of the Germans), in *Laminaria digitata*, and I have seen something of the same kind, though not so distinctly as in his figure, in a vertical section of *Lessonia fuscescens*.

73. In the simplest Algæ there is no distinction of root, stem, or leaves. Some, in fact, consist of nothing more than cells, either entirely free, or floating in a common gelatine, and are multiplied by a constant division of the endochrome. Where, however, reproduction takes place by means of a spore, as in *Isthmia*, there is very generally something, however slight, of the nature of a stem, though the produce of this spore may, for many generations, be propagated only by division; and, in

such cases, the only semblance of a root is a little dilatation of the base, or occasionally a few divisions, consisting either of a single row of cells, or, where necessity requires, of a larger mass. In the higher Algæ, as in the large species of *Laminaria*, the rootlike processes acquire a considerable size, the exposure to

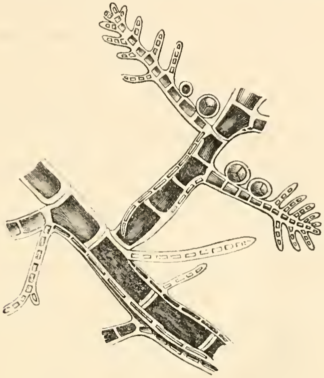

Fig 26.

Branch of *Callithamnion Hookeri*, from Eng. Bot. t. 2938, compared with specimens from Mrs. Griffiths, and Mr. Ralfs.

heavy swells and stormy seas necessitating a strong adhesion to resist the mechanical powers opposed to them. Where there is little danger of disunion the attachment is proportionally slight; and where, as in *Sargassum* and *Macrocystis*, the individuals are destined to float as parts of large fields, sometimes miles in extent, on the surface of the waves, the plant often separates from its primary attachment altogether, and multiplication takes place by a constant re-division of the frond, as in the lower Algæ.

74. The simplest Algæ consist of mere cells; more complicated forms arise, first, from the articulation of such cells, end to end, by means of transverse partitions, and then, by the addition of lateral cells by means at once of transverse and longitudinal dissepiments. According to the proportion in which these two processes are carried out, we have, on the one hand,

such structures as *Chordaria*, representing simple or branched bodies like whipcord, or foliaceous expansions, often of considerable breadth, as the larger *Ulvæ*. By a still further differentiation, we have, at once, bodies consisting of condensed and often elongated tissue, analogous to stems, and foliaceous expansions resembling leaves. We cannot, however, regard these as of exactly the same nature as their analogues in Phænogams. If we compare the different species of *Nitophyllum*, we shall perceive that the midribs of the leaves are the same organs with the stems, and that the fronds themselves, however they may simulate leaves, and answer the same end of exposing a greater surface to the surrounding medium to profit by its influences, have, by no means, the same organic value. The main end is rather one of nutrition than of aeration, though it is true that, in certain cases, even the leaves of Phænogams may, on occasion, answer both ends at once. But there, at any rate, analogy ceases; they are not, like the leaves of Phænogams, essentially symmetrical organs, on the due arrangement of which, after certain laws, the formation of the fruit-bearing organ depends; for there can be no pretence that the fruit of either kind is a transformation of any external organs, in the same sense in which it is understood in Phænogams.

75. There is, however, in many species an additional resemblance to true leaves, in the fact that, in certain conditions, they are deciduous, and re-appear the following year in new beauty, though not from buds, in consequence of nutriment stored up in the thicker and firmer part of the plant. Every one, for instance, who has observed these productions in their native spot, knows how vast a difference there is between the winter and summer state of *Delesseria sanguinea;* and though, perhaps, less generally observed, a series of the larger *Laminariæ*, in their progress from a little strap-shaped frond to the enormous whips with a hundred thongs, heavy enough to load a man, present a constant development of a new frond at the base of the old one.

76. It will be seen presently that these productions vary no less in colour than in form and structure; and, within certain

limits, such variations are indicative of, or at least accompany divisional characters. Some possess a beautiful herbaceous green, others exhibit the bright hues of flowers, and there are few tints which are not displayed by individual species. Next to green, however, the most prevailing tint is pink, passing into various shades of purple; or, on the other hand, olive, from a bright tawny or golden green to black. Even pure blue occurs amongst the lower Algæ. The colour of Algæ does not require much intensity of light for its development. Many species of beautiful colours grow at depths where the light must be so small that no Phænogam could exhibit anything of its proper hue, supposing it possible for its blossoms to be developed under such conditions.

77. It has been long known that the green matter of Priestley, consisting of the lower Algæ and their germs, acts on the atmosphere like the leaves of Phænogams. But, according to Aimé, as quoted in Payer's Botanique Cryptogamique, p. 17, the colour of Algæ is, in this respect, indifferent; and marine Algæ in general absorb carbonic acid, and disengage oxygen, under the influence of the sun, exactly as Phænogams. The quantity of oxygen disengaged by them is said to be immense. M. Aimé collected nearly two pints from a space of about two and a half square yards, by agitating the fronds. I believe, however, it will be found that some of the *Oscillatoriæ* disengage noxious gases. *Chara* is certainly no Alga, and, therefore, I have no reason to speak of its peculiarities here.

78. Algæ, in some of their varied forms, occur in all parts of the globe, reaching the utmost confines of vegetation, and, are, perhaps, capable of flourishing under greater extremes of temperature than any other organised beings.* Within certain depths which, however, descend in some cases to very numerous fathoms † they abound in both fresh and salt water,

* It is, however, *Diatomaceæ* only which extend so far. Animals abound towards the South Pole, far beyond the limits of most Algæ, and Lichens ascend to greater heights.

† *Fucus vitifolius*, for instance, was found by Humboldt, 192 feet below the surface. It could receive there only half the light of a candle,

and occur whereever water trickles down constantly, or where the soil or rocks are moist, for where there is sufficient moisture, full exposure is by no means detrimental to their growth. If the doubtful genus *Leptomitus*, and its allies which grow on putrid or unhealthy animals, and the so-called Algæ, developed in the intestines of *Julus*, be eliminated, there is scarcely one that can be considered truly parasitical; or, with the exceptions before indicated, deriving any nutriment from the soil on which it is fixed.

79. As regards their distribution over the globe, like other Cryptogamic plants, their limits are extensive; nevertheless there are more marked features than might at first be supposed, from the constant motion and the continuity of the medium in which so great a portion of them grow. Many, however, flourish at depths where the warmth of tropical suns, apart from currents, is felt, and in similar temperatures of the sea, there is certainly a greater difference of species than in Fungi or Lichens. Under given atmospheric conditions, neither genera nor species of non-marine Algæ vary much; at any rate, there is a very close resemblance between those on the Indian mountains, and under analogous conditions of climate, though with the intervention of thousands of miles. Amongst many of the lower Algæ, such as *Oscillatoria*, *Calothrix*, &c., it is very difficult to speak of species, because the species themselves are often very loosely defined, and it is almost impossible to judge of such productions merely from dried specimens. It is a remarkable fact, however, that, abundant as the red-snow is in the European regions, it never once occurred in the whole of Dr. Hooker's extensive journeys amongst the loftiest mountains in the world, though there were Algæ, Lichens, and Fungi enough, which could be identified with European specimens. The *Desmidiaceæ* of other countries than Europe and North America have been, at present, but little studied, nor does it appear that they are, in reality, numerous. Dr. Hooker's Indian collections show but a trace of them. The *Diatomaceæ*, on the contrary, occur

at a distance of one foot, whereas *Lepidium sativum* is scarcely greened by the light of two Argand lamps.—*Pers. Narr.*, vol. 1, p. 88.

throughout the world, and extend beyond the limits of any other vegetables. Their siliceous coats render the characters by which they are determined capable of perfect preservation, and though the species vary greatly, still, both as regards species and genera, different regions of the world produce altogether different forms, together with a certain quantity of cosmopolites; and many now existent, are identical with, or at any rate, extremely similar to species occurring in strata anterior to comparatively recent alluvial deposits. Amongst the lower Chlorosperms, there are a few forms which are peculiar to particular districts, but, as research extends, the numbers of these will probably be greatly diminished. The curious *Trypothallus anastomosans*, Hook. f. and Harv., of the Antarctic regions, is identical with Kützing's *Palmodictyon viride*, or, at any rate, belongs to the same genus.

80. As, however, we approach the larger and more important forms of the Algæ of any of the three great groups, we find some marked examples of particular distribution.* The great feature of our own coasts is the extreme abundance of *Laminariæ*, not, indeed, of species, but of individuals; but as we get further north, especially on the western coast of America, and the opposite coast of Asia, they increase immensely in number and importance. On the contrary, the species of *Sargassum* require a higher temperature, and, in consequence, are unknown upon our coasts, except as wanderers. In the southern hemisphere, we have a host of most important Algæ, belonging to the genera *Lessonia*, *Durvillæa*, &c., which are altogether unknown in northern regions. *Caulerpa*, again, is a genus but little known in European Floras, except in Spain and on the northern coast of the Mediterranean. It is represented, to a certain degree, by a few species of *Codium*, but our sands produce merely a few tufts of *Vaucheria* without a trace of *Caulerpæ*, which are so remarkable in many warmer climates for the singularity of their mode of growth,

* In all that relates to the distribution and classification of Algæ, I must acknowledge my obligations to Prof. Harvey, especially in his work on North American Algæ, published by the Smithsonian Institution.

and sponge-like habit so different from that of most Algæ. But species have their appointed tracts, even as genera. The common *Fucus vesiculosus*, for instance, which is so characteristic of our coasts at mid-tide, is not known in the Mediterranean except as drift, though it grows and even fructifies there in floating masses, assuming, sometimes, peculiar forms. The distribution of species is, however, greatly modified by the nature of the currents. Sub-tropical species, therefore, which occur only at the most southern extremities of England, occur on the side of Ireland exposed to the warm currents of the Atlantic as high as 53° ; and to the same cause are due, most probably, the broad forms of *Desmarestia* in Loch Swilly, identical with those on the Spanish coast, though search might probably be made in vain at intermediate points. Seasons, too, have more influence than might be expected on the growth of Algæ. Dr. Harvey has observed, for instance, that *Padina Pavonia* is much influenced by comparative warmth, though it has a wide geographical range ; and such species as grow in shallow pools are more likely to be affected than deep sea species, for such isolated spots, in certain states of the tide, will, sometimes, attain a marked increase of temperature. Slight changes of temperature have, in fact, a greater influence on Algæ than on most other plants. In general, they are impatient of extremes or of exposure to strong light, as may be easily verified by any frequenter of our coasts. Some species are so delicate that a very short exposure is sufficient. Shallow pools, which are capable of being heated on the ebb of the tide, rarely afford Algæ in good condition.

81. It might be expected that most of the seaweeds which are common on the western coast of Europe, would be more or less so on the opposite coast of America, and this is true to some extent ; but though *Fucus vesiculosus* and *nodosus* are characteristic forms of the American coast, *Fucus serratus* is entirely wanting, and other species, almost equally common with that in England, are either unknown or extremely rare. These species are, however, compensated by several kinds of

Laminaria unknown to Europe. The truth, however, is that on a considerable extent of the coast, as far as Cape Cod, the species approximate more than our own to Arctic or sub-Arctic forms. Proceeding to the south the Northern Fuci cease, and are gradually replaced by *Sargassum*. The *Callithamnia* and *Polysiphoniæ* increase in beauty, *Delesseria Leprieurii*, a New Zealand species, occurs, and the tropical *Bostrychiæ*, one of which is found in company with the last-mentioned species, abound in the æstuaries, till, in the Southern states, the forms cease to be those of Western Europe, combining the features of the Mediterranean Algæ with those which are perfectly tropical. Species of *Caulerpa* abound, and numerous allied genera belonging to Mediterranean or West Indian forms, remarkable for the large quantity of calcareous matter deposited in their tissues.

82. A long list of fossil Algæ is given by Endlicher, compiled by Unger from the works of Sternberg, Brongniart, Lindley, and others. Such productions, where the determination necessarily depends on outward form only, and not on intimate structure, are always more or less doubtful. The Algæ most likely to be preserved in a fossil state are doubtless those calcareous species which resemble corals. None such, however, have at present occurred in any geological formation. The genera enumerated by Unger, as far as they resemble in name those proposed for recent Algæ by Algologists, will shew the supposed affinity of the fossil species, *Confervites, Caulerpites, Codites, Encœlites, Haliserites, Zonarites, Laminarites, Sargassites, Cystoseirites, Halymenites, Sphærococcites, Chondrites, Rhodomelites, Delesserites.**

83. Amongst the organic remains contained in amber, none seem certainly referrible to this division, though Algoid forms appear, depending on the motion of bubbles of air in a resisting medium, or other physical causes. The tripoli of tertiary form-

* An actual inspection of specimens arranged in museums, under these and other names, leaves an impression that there is not one of them which is rightly referred to Algæ. Broken specimens of *Oldhamia*, an undoubted animal, resemble closely some *Conferva*. Perfect specimens, however, at once preclude such an affinity.

ations, however, contains many undoubted *Diatomaceæ*, and some indications of these organisms appear in flint and opal,* as also of *Desmidiaceæ*.†

84. The economical purposes to which Algæ are applied are various ; but they are not now of so much importance as they were before modern improvements in chemistry taught a cheaper mode of obtaining carbonate of soda from common salt. The preparation of kelp, which gave employment to so many men, and which was a source of such large emolument on many of our rocky coasts, is now almost obsolete, and there is no prospect of its being revived. A small quantity, however, is still prepared for the manufacture of iodine, which was first discovered in the lees of kelp, and is so important in medicine. The vegetable Æthiops is prepared by burning *Fucus vesiculosus* in a covered crucible. It is given in doses of from ten grains to two drams, and is said to be more efficacious than burnt sponge in scrofulous disorders. Its virtue is doubtless due to the small quantity of iodine it may contain, to which also is attributable the benefit of sea water in similar disorders. Calcified sea-weed is especially useful in the cure of fibrous polypus of the uterus, for which the Kreuznach waters have long been celebrated, in consequence of their containing the same principle, (Med. Times, Aug. 18, 1855.) The principal use for which the large masses of seaweed which are thrown upon the coast are now employed, is in the preparation of manure, and it is to this that the fertility of many a district is due, as, for instance, the Isle of Thanet, which has for years sent to London the best English corn which appears in the market.‡ A few species, such as *Alaria esculenta*, *Rhodymenia palmata*, *Iridæa edulis*, &c., are regularly sold in the Scotch markets; and I can myself bear witness on more than one occasion, at so late a period as 1823, to being able to procure no other food amongst the Western Islands. *Chondrus crispus* and other Rhodosperms have long been sold by chemists for the preparation of a sort of blanc-

* Ehrenberg in Poggendorff Annalen d. Phys., 1836. Ann. d. Sc. Nat., Sér. 2, vol. 7, p. 27. (Zool.)

† Turpin, l. c., p. 129.

‡ Lewis, Hist. of Tenet,1 723, p. 13.

mange; but they are now largely employed, even in the central parts of England, for feeding pigs, in the form of a jelly mixed up with meal and other ingredients. They contain a considerable quantity of gummy and amylaceous matter, and, possibly, some albumen, to which they owe what medicinal property they possess, for they do not appear to contain iodine. According to Schmidt, the jelly of carrageen is identical as to its chemical formula with starch and sugar, $C^{12} H^{10} O^{10}$. Pereira considers it a distinct body from gum, starch, and pectin. Nearly the same substance exists in the Ceylon Moss, and, probably in many allied Algæ, as in the Corsican Moss, *Plocaria Helminthochorton*, which contains besides a minute quantity of iodine, and has, perhaps, no active qualities. A more delicate jelly is prepared from *Gracilaria lichenoides, spinosa*, and *Gigartina speciosa;* the use of which is, however, confined, almost exclusively, to the East or Australia. It is a mistake to suppose that the Chinese swallows' nests belong to the same category, since the substance of which they are formed is secreted by the birds themselves. *Gracilaria tenax*, together with some other species, however, affords another more important substance, viz., a glue, cement, or varnish, which is extensively used in China. *Durvillæa utilis* is employed to thicken soup in Chili. One of the best edible preparations from Algæ is the laver, which is, however, more used in the western than the eastern parts of England. Few condiments are more esteemed than this, where the taste has become habituated to its use; but, like olives, it is seldom approved at first. It is, no doubt, a very wholesome food, but its use is not likely to become more widely diffused than it is at present. A species of *Nostoc* is largely consumed in China as an ingredient in soup; and an allied Alga has been found a welcome article of food in the Arctic regions. The cattle in Scotland and Norway browse upon the seaweeds at low water; and the succulent branches and fronds of the *Caulerpæ* are the favourite food of turtles. The whole tribe affords nutriment for hosts of mollusca and fishes. Several minor uses are made of Algæ, such as the manufacture of handles for tools from the thick stem of *Lessonia fuscescens*, and some other species, and of fishing lines from

Chordaria filum. The siliceous cases of some of the *Diatomaceæ* are valuable test-objects for microscopes, and are used for polishing.

85. A few words on the mode of preserving Algæ for the herbarium may not be amiss in a treatise like the present. Few objects are more beautiful when well preserved; but a great deal depends upon neatness of manipulation. The fresh water Algæ, for the most part, do not make specimens beautiful to the eye, and the distinguishing characters of very many can only be retained by mounting small specimens in fluid, according to the method which will be described at the end of the volume. Useful specimens of many, however, may be preserved for the herbarium by floating them in water and slipping paper beneath them, or by simply drying with as little pressure as is needful to secure neatness and easy preservation in the herbarium. The gelatinous species will not, however, admit of much pressure, and it is often necessary to dry the specimens partially before they are at all compressed. The great difficulty to contend against in the larger olivaceous Algæ is their chemical constitution, in consequence of which efflorescence is apt to take place, and dampness to ensue, which causes mould, and spoils the beauty of the specimens. It is perhaps impossible to avoid these inconveniences altogether; but after the specimens have been washed with fresh water to remove any salt which may adhere to them, careful drying between well-dried paper, &c., frequently changed, will, in a great measure, secure the desired end; the smaller specimens may be preserved by floating them in water. As regards Florideous Algæ, care must be taken that the specimens are not placed longer in fresh water than is absolutely necessary, as it is fatal to the beauty of many. A large portion may be preserved as before, by simply slipping paper under the specimens when floating, taking care that the branches lie in a natural position, and by no means artistically expanded; and of the larger species, those which are gelatinous must be partially dried before they are submitted to pressure, while others will dry admirably if frequently changed, exactly after the manner of Phænogams. In no case should the pressure be extreme, so as to compress the stems unnaturally or to destroy their

cellular structure. Many of these may be preserved in masses, provided they can be put by tolerably dry, and beautiful specimens may be prepared at home. The small quantity of salt which adheres to them is, in this case, rather beneficial than otherwise. The preparation of such beautiful samples as those which are distributed by M. Lenormand, requires a great deal of time and neat manipulation; in no case, however, must mere beauty be attained at the expense of utility, the great object in view being the preservation of specimens in such a state as to render every part capable of comparison with similar or allied species. Occasionally, it may be found that oiled paper, fine linen, or glass may be useful for the preparation of particular species, which are apt to cling to the paper which covers them; but any practised hand will soon invent such methods as peculiar properties of individual kinds may require. I do not recommend the use of linen too much, as I have seen many specimens, otherwise of considerable beauty, materially injured by it. The most delicate species may be readily transmitted by post if wrapped in fine muslin and enclosed in thin gutta percha or tin foil. After some days, specimens will be found in a good state of preservation, and as fit for microscopical investigation as when they were taken from their native rocks, provided the quantity enclosed be small. I have received hundreds of specimens from Mr. Ralfs and Mr. Thwaites in this way, which I have been able to study almost as well as if I had gathered them myself. The more delicate Algæ soon decompose, even when kept immersed in salt water; and, in general, the sooner specimens are prepared after they have been brought home, the better, whether free in their gutta percha bag and tin vasculum, or immersed in little flasks of water; and if this be the case in our temperate realms, the necessity will be so much the greater in warmer countries.

86. Algæ, like Cryptogams, taken as a whole, are evidently distributed into a few large groups, each of which consists of other subordinate divisions. If all such divisions are made of equal importance, or if the divisions are more numerous than are really indicated by nature, the effect will be to fritter away general views into mere details.

87. It is not the object of a work like the present to give a history of every systematic change, or of every step by which we have arrived at the present state of knowledge, nor do I feel bound to make room for more modern systems, which have departed from the unity and symmetry which were first sketched out by Agardh* the elder, and have been successively improved by his son, and by our countryman, Dr. Harvey. The modern French Algologists, as Montagne, Decaisne, &c., have also thrown much light upon the subject, but they seem to me to lay too much stress upon the zoospores, in their arrangements. No one appears to feel the real affinities of Algæ better than Dr. Harvey, and there is surely no one one who has had such opportunities of examining them under every variety of climate and locality. The main divisions which he has proposed are three:

1. MELANOSPERMEÆ (*spores olive*).
2. RHODOSPERMEÆ (*spores red*).
3. CHLOROSPERMEÆ (*spores green*).

88. That these divisions are as certainly founded in nature as those of Algals and Mycetals is beyond doubt; but whether the names or the characters which those names indicate, are the best that might be chosen, or whether individual genera are rightly disposed, is another question. The difficulties are most glaring

* According to Agardh's Systema Algarum, published in 1824, the arrangement is, by analogy with the development of Phænogams:

1. Hyalinæ (Diatomeæ, &c.) = Radix.
2. Virides (Confervæ, &c.) = Herba.
3. Purpureæ (Florideæ, &c.) = Flos.
4. Olivaceæ (Fucoideæ, &c.) = Fructus.

According to this system the genera were arranged, but the whole was too fanciful to be permanent. I know of few things to be so much deprecated in science as these fancies. Arguments in favour of design in the work of creation, are only enfeebled by such puerilities, as by all other extravagance and exaggeration (compare above, p. 39). The first division was gradually merged in the second, and, with modifications as to the true affinities of species, the divisions are the same with Harvey's. Lamouroux, in 1813, laid the foundation by the distinction of *Fucaceæ* and *Florideæ*. Agardh was, however, in all probability but slightly acquainted with Lamouroux's Memoirs, or if familiar with them, he did not pay them the attention they deserved.

in the third division, which comprises a considerable number of species which have not green fruit in any stage of growth; or at least not as a primitive stage, for the red spores of the second order sometimes become green in decay. The contrary effect takes place in some Chlorosperms, where the green assumes a deep red, but not rosy tinge, probably by the same process which changes the natural green of leaves into autumnal red. This is not, however, the point to which I allude; there is a considerable number still of species of *Protococcus, Hæmatococcus,* &c., which are essentially rose-coloured. But this is merely one of those cases in which the attributes of the superior order are indicated, as it were, by the first elements. The shades of transition from *Hæmatococcus sanguineus, Bangia atropurpurea,* and *Porphyra* (Fig. 27), the analogue of *Nityphyllum,* are certain, and it is only an unwillingness to adopt colour as a generic character which prevents such species from being dissociated. The characters by which *Botrytis* is held distinct from *Chroolepus,* are scarcely stronger, at least technically speaking. Naturally they are as widely separated as the east from the west. In *Batrachospermum,* we see species possessing the true green of Chlorosperms and the rosy purple of Rhodosperms; and the red species seem at first sight allied to *Glœocladeæ,* the green to *Chordariaceæ*; there is, however, no close definition even of species, though, to the eye, apparently so distinct, and the coloured individuals are, probably, mere analogues, and no proper denizens of a higher order. In the tribe of *Oscillatoriæ,* there is frequently a deep purple, and sometimes even a rosy red. The waters of certain lakes, for instance, even at a distance, are red from the diffusion of *Lyngbya prolifica,* Grev. Again, in the *Diatomaceæ* there is seldom a grass-green colour, but rather a yellow olive (lederbraun, as it is called by the Germans), sometimes approaching to a golden tint. Making allowance, then, for a few exceptions, which, from the very nature of vegetable productions, will occur in every systematic arrangement, the following characters may be proposed:—

1. Chlorospermeæ.

For the most part green, but varying occasionally to olive, purple, or other tints. Reproductive bodies, zoospores, provided with various ciliary appendages, often resembling spermatozoids; or inactive cysts, filled with endochrome. Spermatozoids rarely present.

2. RHODOSPERMEÆ.

Rose-red, or purple, rarely inclining to brown or green. Fruit—*a*, spores contained in particular conceptacles, either external or immersed: *b*, tetraspores, mostly immersed in the fronds, rarely contained in particular conceptacles, arising from a cell whose endochrome is quadripartite, and which ultimately separates into four distinct bodies. Antheridia often on distinct plants filled with active spermatozoids.

3. MELANOSPERMEÆ.

Olive green, inclining sometimes to brown, monœcious or diœcious. Spores, olive-coloured, either naked or contained in conceptacles, sometimes arising from the division of an endochrome into two, four, or eight. Antheridia often resembling the conceptacles, filled with active spermatozoids. Propagation occasionally by zoospores resembling spermatozoids.

ALGÆ.
1. CHLOROSPERMEÆ.—Spores green, often resembling spermatozoids; active or inactive. Monœcious. Spermatozoids, rare.
2. RHODOSPERMEÆ.—Spores red. Fruit twofold. Diœcious. Spermatozoids general.
3. MELANOSPERMEÆ.—Spores olive. Diœcious or Monœcious. Spermatozoids, general, or represented by similar zoospores.

89. It will be observed that there are two distinct modes of propagation amongst Algæ, the one by zoospores, the other by inactive spores. This circumstance is proposed by Thuret and others as the foundation of a system. It seems, however, that by such an arrangement, plants of close affinities are widely separated. No one, for instance, can deny that the species included under the old genus *Vaucheria* are closely allied; and yet, if this system is adopted, the species must be widely separated from each other. *Caulerpa* propagated by zoospores will then have nothing to do with *Vaucheria* propagated by inactive spores; while *Laminariæ* will be separated from *Fuci*, with which

they are so evidently connected. Besides, the zoospores occasionally arise from impregnation, as in *Œdogonium* and *Bulbochæte.* The same objections apply to the zoosporous and aplosporous divisions of Decaisne.

90. There is something attractive in the main divisions proposed by Kützing of *Isocarpeæ* and *Heterocarpeæ*, but strictly speaking, the tetraspores of the rhodosperms are not fruit at all; they are only a sort of buds, and in consequence, the plants which bear them are more luxuriant than those which bear the true fruit. Neither is the fruit always of one kind only in the other division. *Stilophora*, for instance, with several other allied Algæ, bears two distinct forms of fruit, each containing zoospores, both of which reproduce the species. *Bangia*, moreover, and *Porphyra* ought by no means to be in distinct main divisions, while the red-spored species of *Hæmatococcus* pass gradually into *Bangia.* Besides which, the seaweeds (*Fucoideæ*) are scarcely more nearly allied to *Conferva* than they are to *Chroolepus.* If, however, such names as *Chlorospermeæ* and *Rhodospermeæ* were substituted, we should, with a few modifications, have undoubtedly two tenable groups, and the first of these, when divided into two, would make two equivalent with the first and third of Harvey. As regards the subordinate divisions, they are far too numerous, and separate plants closely allied to each other. I see no advantage, therefore, whatever in adopting Kützing's rather than Harvey's arrangement. The arrangement of Fries into *Fucaceæ*, *Ulvaceæ*, *Diatomaceæ*, is far inferior. It is universally admitted that the divisions of Decaisne are not tenable, but perhaps no one has contributed more than that excellent botanist, especially in conjunction with M. Thuret, to an accurate knowledge of these plants. It is scarcely necessary to notice that of Zanardini,* which has the disadvantage of joining *Fucoideæ* and *Florideæ* in one group, while it separates nearly allied species into another. Endlicher divides Algæ into three orders: 1. *Confervaceæ*, 2. *Phycoideæ*, 3. *Florideæ*, which are, as nearly as possible, synonymous with

* Saggio di Class. delle Ficee, 4to, 1843.

those of Harvey; and his names might be adopted, should those of Harvey displease. I do not, however, approve of *Vaucheria* being arranged with *Phycoideæ*, or separated from *Caulerpa*, nor of several of the other details. It remains only to notice the system of Montagne in his article *Phycoidées*, in Orbigny's dictionary. He divides Algæ into three families: 1. *Zoospermées*, 2. *Floridées*, 3. *Phycoidées;* which, with exceptions as to details, are equivalent to Harvey's three divisions. The *Vaucheriæ* and *Spongodiæ* are, however, as truly zoospermic as any of the first division, and cannot, I think, be separated from it; and certainly *Caulerpa* ought not to be in a different main division from *Vaucheria*.

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1. CHLOROSPERMEÆ.—*Harv.* (1841. 1852.)

Chaodiniæ and Confervæ, *Bory.* 1823.—Hyalinæ and Virides, *Ag.* 1824.—Ulvaceæ and Diatomaceæ, *Fr. Fl. Scan.* 1835.—Zoospermeæ, *J. Ag.* 1842, *Mont.* 1847.—Zoosporeæ and Synsporeæ, *Decaisne*, 1842. —Zoosporeæ, *Thuret*, 1851.—Confervaceæ, *Endl.* 1843.—Isocarpeæ (Gymnospermeæ), in part, *Kütz.* 1847.—Gonidiophyceæ, *Zanardini*, 1847.—Diatomaceæ and Confervaceæ, *Lindl.* 1853.*

For the most part herbaceous-green, but varying occasionally to olive, purple, and other tints. Extremely various in form and appearance, often filiform, propagated by the simple division of the endochrome, by the transformation of particular joints, or by the metamorphosis of the endochrome into zoospores. Sexes rarely distinct.

91. When a piece of stone is exposed to the air, and shaded from the sun, or a stream of water flows down a rock, or a bed of snow is long subjected to radiation, greenish or olivaceous and sometimes reddish matter is formed, consisting of variously organised bodies, which belong to this primary group of Algæ. Together with Lichens, they are the first heralds of vegetation;

* None of these are the precise synonyms of *Chlorospermeæ*, because all the authors understand the affinities of certain groups and species differently.

their decay forms a nidus for the growth of minute mosses; soil gradually accumulates from their decomposition, and that of minute Phænogams which succeed them, till the whole surface is covered; the rock itself, if like granite, composed of parts readily subject to deintegration, is by degrees coarsely pulverised, soil is formed, and the surface is ready to supply the wants of man, and the various members of the animal world which administer to his needs, or concur in the preservation of the balance of the organised world, and of the elements by which it is supported. Unimportant, then, as these minute beings may be at first sight, for many of them are quite microscopic, even the more obscure perform an important part in the economy of creation. Physiologically they are of much interest, because they represent the component

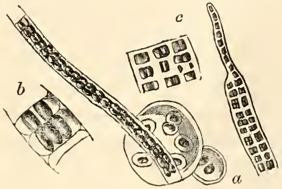

Fig 27.

a. Hæmatococcus sanguineus, Ag., from an authentic specimen.
b. Bangia atropurpurea, Lyngb.
c. Porphyra Boryana, Mont., from an authentic specimen.
All more or less magnified.

parts of which the larger species are formed. It is impossible, for instance, to trace the connexion between *Navicula* and *Schizonema*, *Glœocapsa* and *Seirosiphon*, or by a threefold bond between *Hæmatococcus*, *Bangia* and *Porphyra*, without acknowledging that this is the case, though we may not proceed so far as Agardh in his notions, which extend to the point of considering even Phænogams as made up of Cryptogams. The Cryptogams may indeed be representatives or analogues of their organs, and the study of the one may be illustrated by the other; but we cannot go further consistently with sound philosophy, and perhaps it may not have been the intention of Agardh, after all, however strong his language may be, to convey any profounder notion. In fact the differently coloured species which are referred to one genus on account of perfect similarity of structure, may not, as observed before, in reality all belong to the same category; but as we are restricted in natural history to certain definitions, and bodies which agree with one another, as far as those definitions, go, must needs be associated, we must be content to leave the matter as it is, till a profounder knowledge of the objects of creation may enable us to unravel the order which has been observed in their creation, and the natural relations by which small and great form one harmonious whole.

92. Chlorosperms are divisible into several distinct and well-marked groups, which are again divisible in accordance with nature. The object of the present treatise, however, is not so much the description of each individual form, as such an indication of the more prominent features as may either give some general knowledge of the structure of Cryptogams, or render comparison with higher types simple, and at the same time certain. I shall therefore confine myself to the larger divisions, referring those who wish for more specific information to particular treatises, for which some facility will, I trust, be given by the subjoined lists of the more prominent works and memoirs in each subject.

93. Now there are at least twelve salient groups which cannot fail to attract the attention of every student, of which that which contains the simplest forms shall come first. The others cannot follow exactly in the order of their affinities, as no linear arrangement can possibly be consonant with nature. The groups will be the following.

1. *Palmelleæ.* 2. *Desmidiaceæ.* 3. *Diatomaceæ.* 4. *Confervaceæ.* 5. *Batrachospermeæ.* 6. *Hydrodictyæ.* 7. *Nostochinæ.* 8. *Oscillatoriæ.* 9. *Conjugatæ.* 10. *Bulbochæteæ.* 11. *Siphoneæ.* 12. *Ulvaceæ.* These again form three distinct groups, the first consisting of those species in which the individual cells, rarely forming compound threads or expansions, are the prominent features; the second of those which are essentially filamentous; and the third of species essentially foliaceous.

CHLOROSPERMEÆ.	Cellular (*Diatoma*).	Cells dividing by a simple dissepiment.		*Palmelleæ.*
		Cells dividing by the formation of two new central half cells.		*Desmidiaceæ.*—Green. Cells free from silex.
				Diatomaceæ.—Yellow-brown. Cells siliceous.
	Filamentous (*Conferva*).	Articulate.	Zoospores, minute.	*Confervaceæ.*—Without any compound axis. Articulations mostly longer than their diameter.
				Batrachospermeæ.—Threads partly incorporated into a solid axis.
				Hydrodictyæ.—Reticulated.
				Nostochineæ.—Threads very slender, moniliform, invested with mucus, or surrounded by a gelatinous mass.
				Oscillatoriæ.—Cells very narrow, Threads free, fasciculated, or compacted, simple or branched by apposition.
			Zoospores, large.	*Conjugatæ.*—Zoospores from the union of two endochromes, in the same or contiguous threads, or from division of a single primary endochrome.
				Bulbochæteæ.—Zoospores from division of a secondary impregnated endochrome.
		Inarticulate.	*Siphoneæ.*	
	Foliaceous (*Ulva*).	*Ulvaceæ.*		

1. Palmelleæ. *Dne. Kütz. Mont. Harv.* (*Protococcoideæ* Endl.) Cells free, or surrounded by a gelatinous mass, sometimes stipitate, propagated by the division of the endochrome, which is mostly quaternary, and sometimes transformed into zoospores.

94. The essential foundation of every vegetable is a cell: the very simplest mode therefore of vegetable life which can be conceived, is that of a mass of free cells increased either by partition of the endochrome, or by pullulation from the sides, as in the yeast plant. The two modes, however, seem to indicate two separate types, which may diverge from a common point so as to produce distinct series, while in other cases both modes of increase may be united in the same individual. No true *Palmelloid* will increase its cells by pullulation, and therefore in the very outset such productions as the yeast plant will be looked upon with suspicion—suspicion which is more than confirmed by an intimate study of its different stages of development. There are, moreover, other productions, as *Palmella prodigiosa*, which, from their peculiar habit, seem rather to indicate affinity with fungi. The rapidity with which *Palmella prodigiosa* spreads over meat, boiled vegetables, or even decaying Agarics, is quite astonishing, making them appear as if spotted with arterial blood; and what increases the illusion is, that there are little detached specks, exactly as if they had been squirted in jets from a small artery. The particles of which the substance is composed, have an active molecular motion, but the morphosis of the production has not yet been properly observed, and till that is the case it will be impossible to assign its place rightly in the vegetable world.* Its resemblance to the gelatinous specks which occur on mouldy paste, or raw meat in an incipient state of decomposition, satisfy me that it is not properly an Alga. Neglecting these, we have still a multitude of species, varying greatly in colour, and sometimes assuming tints of red, blue, and yellow, with an admixture of olive, produced, too, in situations where Algæ and not Fungi are to be expected, which, from their simple struc-

* See Stephens in Ann. of Nat. Hist., p. 409; and Berk. in Gard. Chron., 1853, p. 515.

ture and mode of propagation, are united under one common name of *Protococcus*. One of the most familiar examples is the *P. cruentus*, which is to be found at the northern base of almost every wall, provided it be sufficiently damp, looking as if venous blood or the sediment of port wine had been poured upon the ground or stones. Such productions may sometimes be the infant state of more complicated organisms, but there is no reason to believe that such is the case in the present instance, nor in several other similarly constituted species. They are more or less gelatinous, in proportion as a greater or less quantity of mucous matter is secreted from the surface of the spores, or from the greater or less degree of solubility of this matter; but the gelatinous substance is by no means to be considered as primary, or approaching in any respect to what the Germans call *urschleim*, a primitive jelly, which they conceive to arise from chemical combinations, and so in process of time to give rise by spontaneous generation to reproductive globules. In some cases, it is not possible to see the mode of propagation very clearly, in consequence of the diminutive size, but wherever it is visible it seems always to arise from division of the endochrome. At any rate, in the red snow, *Protococcus nivalis*, we have a distinct and repeated division of the endochrome into four, and attended by such curious phænomena, as to have made it a question whether it belongs to the vegetable kingdom at all.* The red snow has long been the wonder of our Arctic voyagers, and travellers among the Alps, but its curious characters do not admit of examination from dried specimens merely. Fortunately a similar, if not the very same production (Fig. 8, 9), grows abundantly in many exposed situations, and living specimens have afforded Cohn and others opportunity of study. In the very confines of the order, we thus become acquainted with the striking resemblance which is exhibited by certain states of Algæ and Infusoria: resemblances which are so close as to be perfectly convincing that we must greatly modify our notions of the distinctness of

* Shuttleworth sur la matière colorante de la neige rouge. Bibl. Univ. de Genève, Feb. 1840.

animal and vegetable life, if we wish them to agree with fact, and not with mere arbitrary theories.

95. If the genus *Protococcus* is to be confined to simple forms, it is clear that several of the so-called species referred to it by Kützing, must be erased ; it is, however, certain that some of the substances in question are mere elements of other productions, and that, inasmuch as the species must either be propagated by the individualising of the granules contained in their protoplasm, or by the division of the protoplasm by dissepiments, we must either have two series of forms, or two modes of propagation must be common to the genus, if not to every individual in it.* The phænomena exhibited by *P. pluvialis* are rather in favour of the former view ; and if so, it will be impossible to distinguish some of the larger *Protococci* from such genera as *Glœocapsa,* the characters of which depend upon the higher development of the spores, and the numerous coats of which the cellular walls consist. The fact is, however, that the limits of the numerous genera proposed by authors, and more especially by Kützing, are by no means fixed. Indeed, Kützing himself looks upon many of his species as mere forms, but if every form is to have a name, there will be no limit to spurious species, and no chance of ever arriving at a natural arrangement; for it is clear that, if in nature there is really a distinct plan, every intrusive species must tend to derange it, or to render the plan itself obscure. Kützing indeed points out, in his work on German Algæ, different species of *Scytonema,* of which he believes certain kinds of *Glœocapsa* to be forms. This and many other similar points were long since detailed to me, by Mr. Thwaites, in the course of an almost daily correspondence ; but unfortunately he was unable to publish the full result of his observations

* It is probable, that wherever propagation takes place by the mere division of the endochrome without any transformation, we have either early stages of other Algæ and Cryptogams, or mere propagation by germination. In some species, Zoospores are produced, in others, spores by copulation, and similar appearances may hereafter be discovered in all. Some *Desmidiaceæ* and *Diatomaceæ* may grow for years without forming a spore, the propagation being carried on meanwhile by mere division.

before he went to Ceylon, and the duties of his station require so much active labour, that he has been obliged to confine his thoughts and care principally to them, to the neglect of his former studies, a circumstance of much regret to all lovers of Crytogamic Botany. Some *Glœocapsæ*, undoubtedly, are states of more highly organised forms, as *Ephebe*, which clearly does not belong to Algæ at all, but to the gelatinous Lichens. It is probable, however, after all, that there may be real species of these lower genera; species, that is, which do not undergo any further transformation; for mere similarity of form or structure does not always point out similarity of essence, or we could not distinguish the cellular state of some animal organisms from their analogous forms amongst vegetables. Whatever be their nature, few objects are more beautiful under the microscope, than some of the higher and more perfect forms, and few give a better opportunity of studying the development of cells, whether as regards their division or the nature of the walls. One of the most curious forms, perhaps, is that assumed by some species of *Glœocapsa*, in which the inner membrane repeatedly bursts through the outer, though always adherent behind, so as to form a gelatinous mass of annulated threads, with a bright eye at the tip of each.* The endochrome is occasionally bipartite, and then each new endochrome acts for itself. The species which I

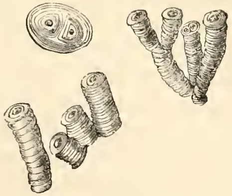

Fig. 28.

Glœocapsa Hookeri, Berk. & Hass.

Threads and spores highly magnified, from specimens communicated by Sir W. J. Hooker.

* Dr. Gieswald has figured a similar appearance in the mother-cells of the pollen of *Cucurbita*. Linn. xxv., tab. 1, fig. 30.

have chosen for illustration, is one detected on the chalk cliffs of Norfolk, by Sir W. J. Hooker, and, perhaps, the group is incapable of any higher development. Other forms depend upon the comparative compactness of the gelatinous mass in which the reproductive bodies are contained, and on the cellular structure assumed by some, as in *Botrydina*, from the close pressure of the several component cysts.

96. The next group is that of *Palmella*. If the figures of Kützing,* relative to this group, be examined, there will be seen in many, an evident trace of slender, supporting threads. Mr. Thwaites,† however, seems to have been the first who properly described this structure, and it is probable

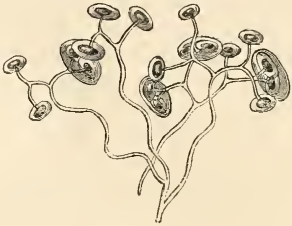

Fig. 29.

Palmella botryoides, Greville.

A portion of the threads which radiate from a large central cell, forked at their tips, and supporting on them elliptic cells, surrounded with gelatine, highly magnified. From a specimen communicated by Mr. Thwaites. Compare Nägeli Gattungen Einzelliger Algen, tab. 2. E.

that it belongs to the greater part of the species,‡ and that some which do not really possess it, would be better associated with the group first mentioned (95). There seems in these to be rarely any such multifold division of the endochrome, or adherence after division, as often prevails there. The spores them-

* Tab. Phycologicæ, tab. 19, iv. 21 ; v. 25 ; i. and v. 26 ; i. and ii.

† Ann. of Nat. Hist., vol. xi. p. 312.

‡ A figure of a new species of *Coccochloris*, *C. Brebissonii*, Thw., is given in Ann. of Nat. Hist., March and April, 1849. This possesses the same filamentous supporters as *P. botryoides*. The structure of the frond of *Synalissa* and *Paulia*, two gelatinous Lichens, exactly accords with that of *Coccochloris*.

selves, too, are for the most part oblong, and point already to some of the lower *Desmidiaceæ*. In *Palmoglœa Meneghinii*, at least, there is a distinct coupling of neighbouring spores; and Brébisson has noticed a similar fact in *Coccochloris protuberans* and *rubescens*, while the transparent peduncles point in the direction of certain *Diatomaceæ*. The limits of this group are uncertain, from the true nature of all the species being at present imperfectly known, and, consequently, some of the more compact forms, such as *Entophysalis*, *Hydrococcus*, and *Palmophyllum*, may, for the present, oscillate between this group and the last. In such plants as *Palmella botryoides*, Mr. Thwaites does not consider the bodies figured at the tips of the threads as spores, but as more properly buds, since true fruit is formed in some, by conjugation, and in others, by the conversion of the endochrome into zoospores. The suggestion is one of considerable value, and has an important bearing on those Algæ, which, like *Glœocapsa* and *Nostoc*, seem multiplied solely by division of the endochrome. It should be observed that these bodies, after a time, put on a form precisely like that represented in *Glœocapsa Hookeri* (Fig. 28). The curious genus, *Entospeira*, leads through *Spirotænia* to *Zygnema*. *Palmodyctyon*, Kützing, which is precisely the same thing with *Trypothallus*, Hook. and Harv., is evidently a member of the Protococcoid group. According as the endochrome divides, vertically or transversely, the mass increases in width or length; and as this division alternates after some tolerably fixed law, a network of greater or less width is formed, according to the proportion of vertical to horizontal division.

2. Desmidiaceæ. *Ralfs.*

Cells void of silex, free, or forming brittle threads or minute fronds, increased by the formation of two new half cells in the centre, so that the two new cells consist each of a new and old half cell. Spores generated by the conjugation of two distinct individuals.

97. The genus *Entospeira* leads directly to *Spirotænia*, a member of one of the most beautiful, varied, and singular group of Algæ, which has been admirably illustrated by Mr.

Ralfs.* All agree in their increase by the partition of the mother cell, accompanied by the growth of two new half cells (Fig. 30, *a. b.*). In many cases, the division goes no further, but each half, with its new lobe grows into a perfect whole, and

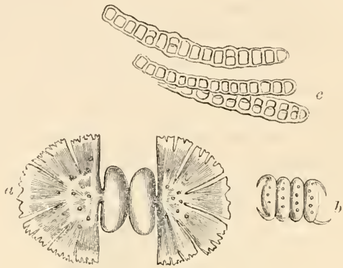

Fig. 30.

a. Micrasterias denticulata, Bréb.

b. Scenedesmus quadricaudatus, Turp., after Mr. Ralfs, both shewing the origin of the new half cells.

c. Threads of *Nostoc verrucosum*, after Thuret.

All more or less magnified.

Fig. 31.

Penium Jenneri, Ralfs, with its spore magnified. From Mr. Ralfs.

Fig. 32.

Closterium acutum, Bréb., free and in conjugation, magnified. From Mr. Ralfs.

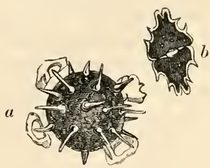

Fig. 33.

a. Euastrum elegans, Kütz.

b. Spore of the same, magnified. From Mr. Ralfs.

* Ralfs' British Desmidiaceæ, 8vo. 1848.

again divides. But this is by no means the case with all, for the two original halves do not always separate, but remain united with their progeny for many generations, thus forming a filiform body (Fig 7, *a*), in which the two primary halves are at either extremity, and the youngest in the middle of the thread: a mode of increase which we shall meet with again in the following tribe. Nor is the connection always confined to development in a straight line. In those species which divide obliquely, an orbicular frond is sometimes formed, as in *Pediastrum*, though seldom one of any remarkable size. The fronds, if they may be so called, or cells, differ in almost every conceivable way, from a right-lined parallelogram or curved bow, to a deeply pinnate or strongly serrated thread. They are, for the most part, strongly constricted, so as to appear like two distinct cells; but this is by no means universal, for in *Closterium* there is no greater constriction than in many species of *Conferva*. They are either smooth, finely granulated, verrucose, or beset with forked spines, insomuch that nothing can well be more curious than the varied outlines which they present under the microscope. Besides the spines, in the genus *Xanthidium*, there is, in the centre of each half-cell, on either side, a curious tubercle, the edge of which is sometimes granulated, but whether it has any especial function or not, is unknown. Mr. Ralfs doubts whether the increase of the fronds, by separation, can be called propagation, but if it be considered in the following way, it will be clear, I think, that it is properly a propagation, though not a fructification. Supposing the two original lobes to be called A, the second B, the third C, and so on, the mother frond will be represented by AA, the second by AB BA, the third by AC CB BC CA, of which CB BC have no part of the original frond, and may, therefore, be considered as entirely new individuals. Another mode of increase is from the swarming of the grains of the endochrome, which become individualised as in other Algæ, and so give rise to a new generation. These bodies are figured with filiform appendages by Braun* in *Pediastrum granulatum*. But, besides these modes of propagation, there is another, respecting which we shall have

* Algarum unicellularium genera nova et minus cognita, tab. 2 B.

more to say under another group, which consists in the union of the endochromes of two contiguous vesicles, in consequence of which, a single large spore is formed in the connecting tube. These spores are mostly globular, but like the fronds themselves, exhibit great differences of surface, so that, apart from the matrix, they may be taken for the sporidia of truffles, or other heterogenous bodies. In many cases, they have no resemblance whatever to the parent frond, and though mixed with them, would never be suspected to have a common origin, until the union of two vesicles, and the consequent spore, should be observed. These, however, when once formed, are propagated by division, exactly after the fashion of the ordinary cells, and in the third generation acquire their normal form, which they may continue to propagate for years, without ever forming a true spore. They differ most materially from the following tribe, in the constant absence of a siliceous coat,* and though it has been attempted to shew that it does exist in the fossil species, more accurate observations have detected deflection of the spines, without fracture, which is inconsistent with such a notion. In one particular group (*Closterium*), distinguished for the more or less entire outline, which is either straight or arcuate in most of the species, there is a peculiar organ at either extremity, consisting of a hyaline or straw-coloured cell, containing a multitude of active molecules, possibly of sexual import. Many of the species of *Closterium* are remarkable for the close-set longitudinal striæ with which the cells are marked. Traces of striæ have, however, been found in a *Tyndaridea*, by Mr. Jenner, and in *Tiresias*, by Mr. Bowerbank. *Desmidiaceæ* are confined almost exclusively to fresh water, though Mr. Thwaites has found one or two species in brackish water, but in every case such species only as also occur in fresh water. Little can be said about their distribution, for few extra-European species are known; and as we travel to the South of Europe, the species appear to diminish in number, their central point, perhaps, being the South of England. There was a trace merely of some *Closterium* in the Himalayan collections of Dr. Hooker and Dr.

* It is conjectured, however, that a small portion of silicate of iron does exist in some species of *Closteria*, communicating a ferruginous tinge.

Thomson. In the United States, a few species occur, and are described by Bailey, and probably the number of these will be much augmented. *Arthrodesmus tænia*, Ehrb., is recorded amongst others. They occur principally where there is some admixture of peat, and in clear pools rather than in running streams, and never where the water is muddy. In limestone countries, where the soil is merely alluvial, they are comparatively rare. This is, however, true, only of the more noble species. Such genera as *Scenedesmus* are, perhaps, more common in limestone districts, than elsewhere, and scarcely a glass of water can be set aside, exposed to the influence of light, which does not produce a host of forms or species. A few species are preserved in a fossil state, in flints and other transparent minerals. It is difficult, at least in comparing recent and fossil specimens, to deny their identity, so precisely similar are they in form. They are, however, principally spores, and not, as Ehrenberg supposes, perfect forms of *Xanthidium*. Several species are described by Mr. H. H. White, in the Microscopic Journal, vol. ii. p. 35. Baily has detected cells of various species of *Closterium* and *Euastrum*, in fossil marls of New Hampshire and New York, and in the marl of Scotchtown, N. Y., below the *Mastodon giganteus*. Spores have been found by Mantell in the grey chalk of Folkestone.

98. Much controversy has existed with respect to their true nature; but at the present day, few advocates will rank on the side of Ehrenberg; for if in some points there be anomalies, as in *Closterium*, their whole history is so evidently vegetable, their mode of increase, growth, &c., that if we refuse them the title of vegetables, we may as well dispute that of the whole tribe of zoosporous Algæ. As for their producing occasionally bodies, endowed with active motion, it is now a matter of certainty, that such bodies exist in a variety of Algæ of very different construction; and it is by no means a fact without exception, that membranes, unless cleansed from every extraneous matter, will not exhibit the reaction peculiar to cellulose, on the application of the proper chemical tests. But, perhaps, the most important point of all, is the fact that, under the influence of light, they give out oxygen, which, added to other

matters, is quite convincing. Some of Ehrenberg's arguments we do not think of sufficient importance to bring forward here. As regards practical use, none at present is known; though doubtless the species exercise their proper part in the general economy of the world, helping to purify the water, and to afford food to mollusca and other animals. In some species of *Closterium*, a distinct circulation has been observed.

3. DIATOMACEÆ, *Ag.* (*Naviculacea*, Ehrb.)*

Propagation and division of cells as in *Desmidiaceæ*. Walls of cells containing a large quantity of silex, often beautifully sculptured. Endochrome golden brown.

99. These curious productions are often united with the foregoing into a single group, but they seem so clearly distinguished by the flinty shell, which is almost always curiously striated, and the absence of pure green colouring matter, that they seem to me to form a group of at least as much importance as the others adopted in this place. As in *Desmidiaceæ*, there are solitary species, and others grouped into lines or membranes; and in the few which have been observed to produce new plants by means of spores, the new productions do not exhibit at first the normal character of the species. The division of the fronds or cells, where it can be observed, takes place precisely in the same way as in *Desmidiaceæ*, and no genus perhaps exhibits this more distinctly than *Isthmia* (Fig. 7, *b*). The genera are more numerous than amongst the *Desmidiaceæ*, and are frequently most acutely characterised; and not only from their peculiar striation, or singular form, but perhaps also from the perfection in which dried specimens exhibit the minutest characters, they are favourite microscopical objects. Both in the solitary and associated species there is frequently a distinct pellucid peduncle, which in those which have a flabelliform frond is dilated above, and in some cases forked, or repeatedly dichotomous. In such cases every new frustule remains attached, the base dilating as need requires; but in the filiform species, the attachment is confined to a single corner, and probably the

* The work of Mr. Smith on *Diatomaceæ* may be quoted here with the same praise as that of Mr. Ralfs on *Desmidiaceæ*. Like that, it is perfectly original, and an important contribution to science.

stem is never developed, except where the plant has sprung from a spore. The siliceous coats of the cells are not only variously marked, but beneath these and the lining membrane there are often little channels. Along the line of suture in disciform or circular frustules, but more generally at the extremity of the valves only, when oblong, linear, or elongated, there exist perforations in the silex, which permit the surrounding water to have access to the surface of the internal cell membrane. Without some such provision, it is almost impossible that there should be any interchange between the contents of the cells and the surrounding fluid. *Diatomaceæ* were long

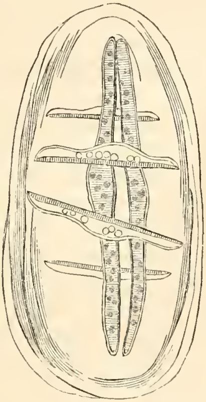

Fig. 34.

Epithemia gibba, Kütz.

From Mr. Thwaites, in Ann. of Nat. Hist., vol 20, tab. 22.* The two original individuals have each split up into two frustules.

believed to be animals, and this view has more especially been maintained by Ehrenberg ; but the discovery of the coupling of fronds by Mr. Thwaites, and the confirmation of the fact by

* I have two or three mounted specimens of different species, and from amongst them, *E. gibba*, from Mr. Thwaites, of *Diatomaceæ* in conjugation, confirmatory in every respect of his observations.

myself, Mr. Broome and others, leaves no doubt that they belong to the same order of beings as *Desmidiaceæ* and *Conjugatæ.* The process of conjugation as described by Mr. Thwaites in *Eunotia turgida,* takes place in the following way. The two frustules being brought near to each other by their concave surfaces, two little swellings arise in each, meeting two similar ones in the opposite frustule. These soon unite and elongate; the dissepiment is absorbed, and the endochromes of the two frustules mix. A spore is then formed in each of the two connecting tubes, which increases in size till it resembles in every respect the parent, except in its much larger size. In the same group, therefore, frustules of very different sizes may occur, especially as the new frustule will divide several times before it acquires the normal dimensions of the species. In some species, as in those which form threads, the new individuals do not resemble the old, but put on very different forms, as in the *Desmidiaceæ,* and have in consequence been referred by authors to different genera. A large quantity of mucus is often generated during the process, in consequence of which, as in our figure, the old and new frustules are bound together in a common group. This jelly is of consequence in determining the difference between old and new frustules in those genera in which they do not differ materially from each other. In *Fragilaria,* only a single spore is formed. In every case, the two parent frustules are split in half by the swelling of the spore. In some cases the new spores acquire a stem, even where the frustules are not normally stipitate. At present, as far as I know, active granules have not been discovered in the cells; and it appears that true spores are far less common here than among the group just described. The species are far more widely diffused, and extend beyond the limits of all other vegetation, nor is there probably a portion of the world where there is sufficient water to allow of their production, from which they are entirely excluded. They flourish both in standing and running water, but they are found, also, on the bare surface of the ground, or on objects, as rabbits-dung, lying upon it; and in South America they occur amongst lichens, upon the trunks of trees. While, on the one hand, they do not altogether avoid thermal springs, they abound amongst the pancake ice of the South Pole, as far south as seventy-eight degrees, where they must occasionally be subject to very low temperature. "Though much too small to be discernible to the naked eye, they occur in such countless myriads, as to stain the berg and pack ice, wherever they are washed by the swell of the sea; and when inclosed in the congealing surface of the water, they impart to the brash and pancake ice, a pale ochreous colour." As the siliceous coats are indestructible under ordinary circumstances, even when these productions have been swallowed by animals, they are readily distinguished, either on examination of the contents of the stomach or of voided excrement. Consequently, where-ever these substances are deposited, they are to be found, as in the penguin rookeries, and other sources of guano, where they remain for ages, having been in the first instance swallowed with the mollusca, of which the food of the birds mainly consists. The shells of the dead animals also gradually subside, and in consequence, myriads are in some situations brought up with soundings. It can be no matter of surprise, therefore, that these bodies, though so minute, are perfectly preserved in a fossil state in several strata, in some instances in such abundance, that they are collected and sold under the name of Tripoli polishing powder, for which purpose they are admirably adapted. Dr. Ehrenberg even asserts, that species are to be found in a living state in situations where they have been propagated from times far anterior to the present modification of the earth, to which man has been assigned as an occupant; but such fancies require the very strongest proof before they can be received as certain verities. Some notion of the extent to which they are deposited in modern days may be conceived from the facts adduced by Dr. Hooker. "The Phonolite stones of the Rhine and the Tripoli stone, contain species identical with what are now contributing to form a sedimentary deposit (and perhaps at some future period a bed of rock), extending in one continuous stratum for four hundred measured miles. I allude to the shores of the Victoria barrier, along whose coasts the soundings examined were invariably charged with *Diatomaceous* remains, constituting a bank which stretches two hundred miles north from the base of the Victoria barrier, while the average depth of water above it is three hundred fathoms, or one thousand eight hundred feet."*

100. But not only are species found in a fossil state which are identical with recent forms, but the trade winds bring over large quantities in what Ehrenberg calls *Passatstaub*, or trade wind-dust, which, sinking through the upper current, streaming from America, into the lower stratum, falls in the form of fine powder. This, however, does not contain for the most part African forms, though apparently coming from that coast, but truly American species, many of which are identical with those from the Antarctic. Another curious fact is, that they are thrown up with volcanic ashes from active craters; but the same power which in certain instances would carry the fish from the sea, would be sufficient to waft such far less perishable bodies, in a state capable of recognition. It would take many pages to go through the different lists of species peculiar to the different parts of the globe; many forms, however, which do not occur at present in our own country, are abundant in certain fossil deposits, and in exotic lands, but by no means to the exclusion of Mediterranean forms from the cold southern latitudes. In the collection made by Dr. Hooker in the Himalayas, whether in hot springs, or in the mountain frosts and streams, the species resemble closely our own; and probably, when they shall have been sufficiently examined, few new species, and certainly no novel forms, will be detected. A few instances will shew in what distant localities the species are found. *Epithemia gibba*, a very common British species, occurs also in Italy and Ceylon; *Epithemia Westermanni* at Wareham and Ceylon; *Actinocyclus undulatus*, Kütz., in various places in England, also in Peruvian guano, and in Virginia; *Triceratum alternans*, Bail., at Poole and Folkestone, and also in Peruvian guano.

101. It is quite impossible to notice every form, we must therefore content ourselves with passing in review merely such as may be most characteristic. There are three principal groups,

* There is a bed of *Diatomaceæ*, at Richmond, in Virginia, on which the town is built, eighteen feet thick.

the first of which contains those with smooth or transversely striate frustules, but neither vittate nor areolate, the second with vittate and the third with areolate frustules. The first comprehends far the larger number of species and the least interesting forms. Some are perfectly free, as *Navicula*, others attached by one surface, as *Cocconeis*; some form long threads, the frustules of which adhere tolerably firmly at their commissures, as *Fragillaria*, or separate alternately, being suspended at a single point so as to form curious chains, as *Diatoma;* a few, in consequence of assuming a circular disposition, are cuneate, as *Meridion;* others approximate some species of *Conferva*, forming straight lines with more or less cylindrical frustules, as *Meloseira;* some, again, have singularly curved discs, as *Surirella campylodiscus;* one group has strongly developed, and sometimes branched stems, as *Gomphonema;* one curious set is always surrounded by copious mucilage, so as to form distinct, and often branched fronds, as *Schizonema*; while *Dickiea* takes the habit of an *Ulva*. They are produced both in fresh and salt water, and even those genera like *Schizonema*, which were once supposed peculiar to the sea, have their fresh water representatives.*

102. We now come to the vittate species, which are known by the fillet-shaped markings on their disc. The species are far less numerous than in the last group, and more common in salt than in fresh water. They grow on Algæ or other marine substances. Many, as *Licmophora*, exhibit beautiful fan-shaped groups, seated on gelatinous branched threads, the tips of which are dilated to bear the frustules. *Licmophora flabellata* is one of the finest microscopic ornaments of our coasts, but it is very easily injured. *Climacosphenia*, remarkable for the moniliform marking on its disc, has at present occurred only in New Holland and Mexico; and *Terpsinoe* in the latter country and tropical America. Several other genera occur on our coasts, as *Striatella*, and one or two beautiful allied objects in fresh water, as *Tetracyclus lacustris*, and *Tabellaria flocculosa*.

* The genus *Schizonema* is not confined to the northern hemisphere. *Schizonema crispum*, Mont., is found in Lord Auckland's group and elsewhere, attached to the fronds of the smaller marine Algæ.

103. The third group contains many exquisite microscopic objects, some of which may be contemplated with fresh admiration every time they are submitted to the magnifier. We have no longer simple, linear, or vittate markings, but the cuticle is cellular or areolate. Some are simple and disciform, as *Coscinodiscus*, or the discs are marked with radiating lines, as *Actinocyclus* and *Actinoptychus*; others angular, as *Amphitetras antediluviana*, which occurs not only in a fossil state, but recent, in England and Jamaica; but curious as these are, the crown of all are such genera as *Isthmia*, (Fig. 7, *b*,) and *Biddulphia*, both of which show, in the most admirable way, the mode of increase of the frustules. In some of these, every frustule is attached by a short stem to its neighbour. Sporangia are rarely formed. As such genera as *Coscinodiscus* and *Actinocyclus*, &c., abound in the Baltic, they are probably not rare in Great Britain. A few words must still be added respecting the curious *Bacillaria paradoxa*, the motions of which I have had more than one opportunity of observing. The frustules, which are long and slender, slip over each other, yet so as always to adhere, so that the whole mass is in motion, though at the same time several groups of frustules are moving in contrary directions. The cause of this motion is wholly unknown, but it is most probably mechanical, and not vital. It consists of a succession of jerks, the return being almost in the same path as the procession. The motion is more or less perfectly isochronal:—"An obstacle is not evaded, but pushed aside; or, if sufficient to avert the the onward course, the latter is detained for a time equal to that which it would have occupied in its forward progress, and then retires from the impediment as if it had accomplished its full course."—*Smith*, l. c. The same author estimates the motion of different species as follows:—

Bacillaria paradoxa,	$\frac{1}{200}$	inch	per second.
Pinnularia oblonga,	$\frac{1}{2000}$	"	"
Pleurosigma strigosum,	$\frac{1}{2400}$	"	"
Nitzschia linearis,	$\frac{1}{2500}$	"	"
Pinnularia radiosa,	$\frac{1}{3400}$	"	"

As regards utility, it is certain that myriads of mollusca feed upon *Diatomaceæ* almost exclusively. Dr. Hooker tells us that he does not remember to have examined the contents of the stomach of any *Salpa* between the latitudes of the N. Tropic and 80° S. which did not contain the remains of *Diatomaceæ*. *Dictyocha aculeata* was universally found in the stomachs of those he opened when off Victoria-land. Tripoli powder is largely used for polishing, in consequence of its being composed of silex, and some species form valuable tests of the power and clearness of microscopes. Though the greater part of *Diatomaceæ* do not readily enter into a state of decomposition, the *Cymbelleæ* form an exception, probably from comparative defect of silex.

4. CONFERVACEÆ, *Ag.*

Threads articulated, simple or branched, attached or more rarely free; mostly of an herbaceous green. Cells generally longer than their diameter. Propagation by minute zoospores, or metamorphosed joints.

104. This is a vast tribe consisting of very numerous species, which are in general of very simple structure, but according to their mode of aggregation, or branching of the threads, exhibit extremely varied aspects. They grow in various situations, both in fresh and salt water: in thermal springs, on the bare soil, when sufficiently moist to afford nutriment, on exposed rocks, on the leaves or fronds of aquatic plants, indeed, in almost every situation in which vegetable life can be sustained; but we must not extend the term to those productions which affect mineral solutions and liquids, impregnated to a greater or less degree with organic matter, for they are mere states of different moulds, which may occasionally be detected in the act of bearing normal fruit. Nor am I inclined to include those nearly colourless species which grow parasitically on dead or diseased animals, as I feel convinced, notwithstanding the very curious phenomena they exhibit, that they are really states of Fungi. If, however, they are to be considered as true Algæ, their place will be here, and I shall, therefore, describe the peculiarities they exhibit under this head.

105. The threads are either simple or branched, and contain a nearly colourless endochrome, as in moulds; and, indeed, it was

long since observed by Carus,* that the portions of a salamander which were above the surface of the water produced a *Mucor*, while those immersed gave rise to an *Achlya*. In the simple species, the endochrome in the clavate tips gradually becomes organised, producing subelliptic bodies with two lateral appendages, by means of which they are enabled to move with great celerity. These escape either by a lateral, or more frequently by a terminal aperture; and as soon as the contents are discharged, the dissepiment becomes convex, the penultimate joint swells, and gives rise to a new fertile articulation. This process is repeated till the vital powers of the threads are exhausted. In *Achlya prolifera*, however, the new sporangia are formed after the manner of the branchlets of a *Cladophora*, on either side, at the base of the effete joint; and this process being repeated, we have a bifid thread. In this case also, the spores have two flagelliform appendages, and in both they give rise to new plants, sometimes germinating *in situ*, sometimes after the discharge of the spores, when detained by means of a delicate membrane, in the shape of a globose head. The flagelliform appendages in *Saprolegnia ferax*, as observed by Thuret, are terminal. The globular sporangia, observed by the same admirable writer, with their spores, resemble so closely those of some of the mucorine Fungi, that I should not hesitate, were there any other instance of the production of zoospores with flagelliform appendages amongst Fungi, about their removal from Algæ. There is still room for further investigation, and, perhaps, some light may be thrown upon the question by examining the growth of the mould, which attacks living flies in autumn under different circumstances. It will, I think, eventually appear that the *Empusa* of the fly is but a form of *Botrytis Bassiana*, and if so, the fungal nature of these productions will be placed beyond doubt. The cellulose of which their vesicles are composed, presents a beautiful blue tint under iodine, and is apparently far purer than in most Fungi or Algæ.

106. A large quantity of the *Confervaceæ* consist of simple unbranched articulated threads, increasing in length by con-

* Act. Nov. Leop. 182

stant division of their endochrome, and propagated either by the rupture of the threads, or by active granules formed within their articulations, and escaping by a regular aperture. They vary in the consistency or breadth of the common tube, which is sometimes gelatinous, sometimes membranaceous, sometimes almost cartilaginous; in the length and constriction of their joints; in the abundance and depth of tint of their endochrome. None of the more typical species seem to form any distinct spores, apart from the zoospores. The branched *Confervæ* are very often marine, but by no means exclusively so, and sometimes attain a considerable size. The tufts which they produce vary much in density, as do their filaments in rigidity; and in one species, which occurs in mountain streams, they are so dense as to present the appearance of solid balls of various size, resembling strongly, in some respects, the hair balls which are formed in the stomachs of some ruminating animals. One species, *C. mirabilis*, Ag., is so large and rigid, as to form a convenient matrix for the development of the spores of one of the red seaweeds, and hence it has been maintained by the elder Agardh, in accordance with his notions as to the metamorphosis of one species of Alga into another, that a *Conferva* is capable of assuming a higher degree of organization, and attaining the dignity of one of the Rhodosperms. A minute inspection, however, of specimens soon detects the fallacy, and exhibits the true nature of the phenomenon. It was said above, that the gelatinous element varies very much. This is the case both in the simple and branched species. In the former instance, the effect is only that of making the common mass more slippery; but where the threads are branched, the increase of this element in quantity and consistence will at length produce fronds, according to the degree of condensation, more or less comparable to those of *Nostoc*. We have, accordingly, delicate *Draparnaldiæ* and *Stygeoclonia*, which hardly hang together, and whose masses are destroyed by anything except the most delicate handling; while in *Chætophora*, the jelly is so firm as to form globose or corniform masses, approaching even the firmer *Rivulariæ* in consistence. In point of structure, there is no material difference, and the endochrome is frequently resolved into active granules. In

Stygeoclonium, however, the endochrome sometimes puts on another appearance, and is divided into new endochromes, after the fashion of some of the simple Algæ, and in *Chæto-phora,* as first discovered by myself, when a very young botanist, near Dunstaffnage Castle, the threads are studded with globose lateral cysts. Müller* informs us that in *C. tuberculosa,* he has repeatedly seen two kinds of cysts, one scarlet, and constituting antheridia, the other larger, and at length producing spores. He further asserts that the female cysts germinate, that the protruded thread is at length incorporated with the elongated antheridium, and that reproductive spores are generated by the mixture of the two endochromes. This requires confirmation, and the more so, because what he describes as the process of germination and development evidently belongs to some *Rivularia.* Kützing† considers his report as fabulous, and I am inclined to adopt his opinion. He confirms his observations, however, so far as the female cysts are concerned. Processes distinct from the branches were many years since pointed out to me, by Mr. Broome, in *Cladophora glomerata,* but not in such a condition as to convince me that they were really fruit.

107. Having once obtained a sporangial form of fruit, the transition to those plants which Kützing has placed in a separate section, under the name of *Chantransiæ,* is very easy. *Chlorotylium,* which has, I believe, been found in Great Britain, is a higher form of *Chætophora,* with a differentiation of certain joints after the manner of *Stygeoclonium,* and fruit like that of *Chætophora.* The fertile joints form concentric zones, in the convex gelatinous mass, according, probably, with successive periods of growth. *Chantransia,* which has clusters of such cysts, is distinguished by a purple tint, and approaches *Callithamnion* in habit, while *Chroolepus* differs from all in its golden colour (changing, however, in the herbarium, to greyish green), and its affecting damp walls, trunks of trees, leaves, and other objects, and never, I believe, growing in water. The fruit of these plants wants further study. *Gongroseira* is at present imperfectly known, but if Kützing's account be quite

* Flora, 1842, p. 513, tab. 3.

† Phycol. Gen. p. 325, tab. 10, fig. ii.

correct, each joint of the terminal bundles of threads is a distinct female cyst.

108. A number of Algæ occur in warm climates, whose real nature is masked by an abundance of calcareous matter. These were formerly, with a few exceptions, referred as corallines to the animal kingdom. Like the underground Fungi, they vary much in structure, and have very different affinities. Some of these seem to be closely related to true *Confervæ*, though often classed with *Siphoneæ*. *Acetabularia*, (Fig. 41,) which in form and marking resembles somewhat *Coprinus plicatilis*, bears a whorl of threads, united laterally into an orbicular disc, seated on a delicate peduncle, with a few free-branched threads springing from the umbilicus. *Polyphysa* is somewhat similar in the disposition of the component parts, which are however free. Several species, though firm, are not calcareous. The genus *Anadyomene* differs only from *Cladophora*, in having its branched threads united into a membrane, which exhibits the most elegant marking. *Valonia* consists of large cells or sacs, which are simple or branched, and repeatedly constricted. Whether there is a dissepiment or no at the constrictions I am unable to ascertain, but in *Dictyosphæria*, the surface of which is marked with the outlines of hexagonal cells, there are strong dissepiments.

109. The typical species are distributed over the whole surface of the globe, some of which luxuriate at the Cape, and in the lower parts of South America, the smaller species ascending to very high latitudes and altitudes. They abound in the islands of the Antarctic, where they generally differ from northern species. *Cladophora crispata*, under various forms, is extremely plentiful in India, descending as low as the banks of the Ganges, where it forms dense woolly masses, studded with *Diatomaceæ* or *Chantransia*, exactly as it might be found in the Thames. Though the northern species sometimes attain considerable size, whether as regards thickness and rigidity, as *Conferva Melagonium*, which Dr. Sutherland has found five feet long, or denseness of mass, as *Cladophora rupestris*, none of them can vie with *Conferva clavata*, or *Cladophora mirabilis*. The aberrant groups are inhabitants of

warm climates. There is no representative on our own coasts, though several occur in the Mediterranean; nor do they appear in New Zealand. *Acetabularia* occurs in New Guinea, and *Dictyosphæria* in Galega and Rawack. *Polyphysa* is abundant in King George's Sound. *Anadyomene* occurs in the Mediterranean, the Canaries, and the South Sea Islands. All of these appear to me nearly related to *Conferva*, from which I think they ought not to be separated, especially while we are ignorant of their fruit. *Confervæ* sometimes abound to such an extent, as to be extremely injurious. After floods, for instance, where the water stands several days, they sometimes luxuriate so much, as on their subsidence to form a uniform paper-like mass, to which the name of meteoric paper has been given. Till the stratum becomes perfectly dry, which is a slow process, except on the outer surface, the smell is often very disagreeable, and the gas generated from it renders the meadows extremely unwholesome. *Confervæ* afford an enormous supply of food to aquatic animals, and when fresh, purify the air by the exhalation of oxygen. Otherwise, they do not seem to answer any especial purpose in human economy. Pliny speaks of the virtue of *Confervæ* in uniting broken bones, and supposes that the name is derived from *conferruminando;* but, like most Latin etymology, this is probably incorrect. The natural derivation is from *conferveo,* on account of the bubbles of air which are given off by the filamentous mass.

5. Batrachospermeæ, *Ag.*

Threads incorporated into a solid axis, surrounded by gelatine, or converted into a cellular tube; branchlets short, fastigiate, whorled, or scattered, sometimes forming interrupted knots; fruit, aggregated or solitary on the branchlets, consisting of metamorphosed cells.

110. A small but very beautiful group of Algæ, consisting of gelatinous threads, variously woven into a branched cylindrical frond. The superficial branches are either scattered over the whole plant, or collected into little knots, which make the plants appear like necklaces. They vary from green to black, passing through intermediate shades of olive or purple. Fruit is pro-

duced either scattered or in masses, and arises from transformed joints, as in some *Callithamnia*, a circumstance which shews a close affinity to *Chantransia*, which differs only in the endochrome. In *Thorea* the branchlets are scattered, in consequence of which no knots are formed; but the habit is the same, and the purple or lilac tint assumed in drying is a confirmation of its relation to *Batrachospermum*. In *Lemanea* there is a most curious departure from the normal form. The threads are at first precisely like those of a *Conferva*. Certain joints, however, are protruded from the sides, after the manner of the first divisions of the thread in *Cladophora;* these rapidly increase both in length and breadth, by means of transverse and vertical division; a cavity is formed in the centre; the walls are lined with large transparent cells from which articulated threads are sent forth horizontally into the cavity, either from every point of the surface or in whorls, insomuch that the structure is almost that of a *Cymopolia*, or *Batrachospermum* turned inside out. The structure was described, independently of each other, by Mr Thwaites and Kützing (Phyc. Gen. p. 322, tab. 19), and is a very curious case of departure from the usual cycle of growth in allied Algæ. Something, however, is still deficient as regards the mode of origination of the large pellucid cells which line the Ulva-like tube, and the formation of the central cavity. It is uncertain whether it arises by absorption, or whether cells are formed round it. *Cymopolia*, which abounds in calcareous matter, has the same cellular membranous central thread as *Lemanea*, but the whorls of the fertile threads are external, while *Galaxaura*, Dcn. (*Alysium*, Ag.) is in structure almost identical, except in its calcareous matter, with *Thorea*.* The zoospores have not yet been observed. The more typical species are for the most part natives of the northern hemisphere, but others, as *Cymopolia* and *Galaxaura*, which contain a good deal of calcareous matter, are found in

* At least according to Decaisne's views. The figure of *Halysium rugosum*, by Kützing, differs materially from the report of Decaisne, who does not coincide with Kützing in his views as to structure. I have not materials to examine the point myself. See Ann. d. Sc. Nat., 2 Sér., v. 18, p. 118. I have not seen Wartmann's Essay on *Lemanea*.

various warm climates, none of the species occurring so far north as our own coasts. *Batrachospermum* occurs in the Ganges, in North America, Hermite Island near Cape Horn, and New Zealand; and *Thorea* is found in the latter country, and in Bourbon. *B. vagum*, of New Zealand, is not distinguishable from specimens gathered on Snowdon. One curious circumstance in the genus *Batrachospermum*, of which, as mentioned above, we shall find instances again, amongst the rose-coloured Algæ, is that the threads of the knot-like masses send decurrent joints down the stem, thus making that compound which was originally simple. The genus is not confined to fresh water; one species at least flourishes in the sea. They are exactly analogous to *Mesoglœa* amongst the Melanosperms, and to *Crouania*, &c. amongst the Rhodosperms.

6. HYDRODICTYEÆ, *Dcn.*

Threads forming a reticulated sac, producing minute zoospores from their endochrome. Zoospores arranging themselves into polygons, and at length uniting and swelling into new nets.

111. A small but singular tribe of Algæ, remarkable alike for the net-like form and singular mode of reproduction. The common *Hydrodictyon utriculatum* is found in ponds, and resembles a long purse with regular reticulations. At first sight, the joints of which the net-work is composed appear like those of an ordinary *Conferva*, consisting of two sacs, one within the other, of which the inner contains a granular endochrome; after a time, however, these joints swell, and ultimately, by the organization of the endochrome, become so many new plants. Dr. Areschoug * has pointed out, in a very interesting paper, the mode in which this change takes place. The granular mass gives rise, at a certain period of growth, to a number of elliptic grains endowed with active motion. These become attached to each other by their extremities, so as to form a net-work; union takes place between the several bodies, and in process of time a new individual is formed, which becomes free by the absorption of the external walls. If the genera *Microdictyon* and *Talerodictyon* really belong to this group, the species grow in salt as

* Linn. v. xvi, tab. 5, and De Hydrodictyo utriculari Dissert.

well as fresh water, and are widely distributed, as in the Red Sea, Sandwich Islands, Atlantic Ocean, and Nagasaki. The affinity of these two genera is possibly rather with *Anadyomene*, to which genus one at least is referred by Dr. Montagne. If these are excluded there is but a single representative, which is too peculiar in its characters to admit of union with any other group. This curious production inhabited the pond in the Old Botanic Garden at Cambridge, for many years. I believe Professor Henslow was the first to point out the origin of new plants from the individual joints, specimens illustrative of which I received from him more than thirty years ago. In this state it is scarcely possible to conceive a more attractive object for the microscope.

7. NOSTOCHINEÆ, *Ag.*

Threads very slender, moniliform, invested with gelatine, which is at length to all appearance common to the mass, but at first apportioned to each individual thread; propagation by the division of the threads, or by zoospores.

112. Though the species of which this section is composed agree closely in character, their habit is very different. The thin stratum of some species of *Anabaina*, differing little in appearance from some minute *Conferva*, when compared with one of the almost gigantic species of *Nostoc*, which float in the lakes of Thibet, or occupy damp ground in New Zealand, seems at first sight to be widely different, and yet there is a close series of forms leading up directly from the most humble to the most highly-developed species. All are characterised by necklaces of spores, surrounded for the most part by firm and copious jelly, of which some privileged joints are larger than the rest. The gelatinous element sometimes forms large wavy expansions or pruniform bodies, but in many it constitutes a mere stratum, sometimes of little density, either floating on the surface of the water, or adhering to the damp naked soil. Thuret was, I believe, the first who directed attention to the mode of increase of these Algæ. He perceived in *Nostoc verrucosum* that the threads broke up into fragments, burst through the common envelope, and became dispersed in the water. In this condition they were endowed with spontaneous motion, a

peculiarity which Thuret observes exists in many Algæ, which frequent running streams, the motile bodies being thus enabled to contend against the current. These fragmentary threads divide longitudinally and transversely, at last constituting a bundle of new threads, which gradually by increase of the gelatinous or filamentous elements, assume the normal form of the species. It is to be observed that, in an early stage of growth, each thread has its own coat of gelatine. The genus *Hormosiphon* (Fig. 21) is therefore not separated from *Nostoc* with sufficient reason. Derbès has recorded the transformation of the moniliform joints into zoospores. This, however, requires confirmation, and it can scarcely be doubted that the fruit, whether consisting of zoospores or not, must be looked for in the enlarged joints. The mode of increase observed by Thuret is probably not strictly propagation, but is rather of the same nature as that in *Palmelleæ.*

113. In *Nostoc* there are, as just said, individual joints which exceed the rest in diameter. These larger joints will in all probability eventually prove to be connected with the fructification. But these swollen joints are still more remarkable in *Anabaina* and its allies, where they are also accompanied by connecting cells, differing from the others in size, but not acquiring a dense endochrome. In *Sphærozyga Carmichaelii* the fruit-cells are oblong, and their endochrome of a vivid green, in *S. Thwaitesii, Broomei,* and *Berkeleyana,* their form is more elliptic, and their colour brown. They are sometimes solitary, but more frequently they follow each other in continuous chains, or in abrupt groups, consisting of from two to five individuals. The connecting cells are sometimes clothed with cilia, in which case they may be either terminal or situated indifferently. In the last-mentioned species the young threads are inclosed, two or three together, in a mucous sheath. This prepares the way for *Spermoseira,* in which there is constantly a membranous tube to each thread. The joints are short, and less decidedly moniliform, the fruit cells more inclined to be globose, and the connecting cells sometimes, though not constantly, pale rose coloured. They approach very near to *Oscillatoreæ.*

114. The species of this group are very widely distributed; a species of *Nostoc*, or according to received nomenclature, *Hormosiphon*, abounds to such a degree in the Polar regions, that it affords a welcome food, consisting as it does of a modification of cellulose, without any deleterious admixture. The species is produced upon the soft and almost boggy slopes bordering on the sea, but is carried about by winds in every direction, rolling over the surface of the ice and snow, and affording a nidus for *Poduræ*, and a little spider, *Desoria arctica*.* It has been found at a distance of ten miles from the land; each plant lies in a small depression in the snow upon the ice. It proved far more palatable than the true *Tripe de roche*, as was indeed probable from the extensive use which is made by the Chinese of an aquatic species *Nostoc edule*, Berk. and Mont., which is dried, and forms an ingredient in their soups. Two species, the common *Nostoc*, which in the northern hemisphere occurs as far south as the Canary Isles, and also in Bolivia, and *N. microscopium*, Carm., were found by Dr. Hooker in Kerguelen's Land: both on wet rocks, near the sea. Dr. Thomson found several species in the salt lakes of Thibet, floating on their surface, and attaining a considerable size, or on the marshy brackish ground. The genus also appears in French Guiana. A very splendid *Sphærozyga* occurred in the Antarctic regions, and the warm springs of India are not without their representative. The species of *Sphærozyga* which occur in such situations are often used as an outward application for glandular affections, and it is possible that they may have some effect, since Henry observed that they contain minute quantities of an alkaline iodide.

115. It has been asserted that these productions are nothing more than states of lichens, a doctrine to which, however, I cannot subscribe; for though it is true that the fronds of the Collemal lichens do contain gonidia arranged in little necklaces, this appears to be a mere case of analogy. The only difference, indeed, which exists between ordinary Lichens and Collemals, is the prevalence of the gelatinous element, and probably as a consequence the greater adherence of the gonidia. The masses

* Sutherland, Journal of a Voyage in Baffin's Bay, p. cxciv.

of *Nostochineæ* are for the most part more or less shapeless and irregular, where they do not assume a globular or elliptic form. But I have a species with a linear dichotomous flagelliform frond, which creeps over naked albuminous soil of the San Pedro, in Texas, where it was found by Mr. Charles Wright. It is *Nostoc flagelliforme*, Berk. and Curt., No. 3809. The substance is firm, but there is no external envelope. One of the most curious genera is *Monormia*, which forms floating masses of jelly on the top of brackish water. The necklaces are of immense length, and, together with the jelly which surrounds them, form branched masses, which wave with the slightest motion of the fluid. In general, the species prefer fresh or brackish water, a few only flourish when fully exposed to the action of the sea. Floating masses are likewise formed occasionally in large ponds or lakes, which assume in consequence a delicate green tinge. Mr. Thomson has described a curious species which he calls *Sphærozyga spiralis*, as producing such an effect, together with an allied Alga which assumes almost a membranous form, to which Morren has given the name of *Aphanizomenon incurvum*.* The lake at Glaslough (sea-green lake) in Monaghan owes its colour, according to Drummond, to *Oscillatoria ærugescens*.†

8. Oscillatoriæ, *Ag.*

Threads articulated, simple, or branched by the diversion of a metamorphosed cell; more rarely by the protrusion of the central cord, consequent on the rupture of its outer coat. Cells generally very narrow. Propagation by minute zoospores, where the mode of fructification has been ascertained.

116. This division is strictly parallel with *Confervaceæ* and *Nostochineæ*, and the species rise gradually in each, from simple to compound forms, *Conferva* leading to *Chætophora*, *Anabaina* to *Nostoc*, and *Calothrix* to *Rivularia*. In deference to established usage, I had determined to keep the two latter distinct, but on mature reflection, it did not appear that I

* Ann. of Nat. Hist. vol. i,, p. 83.

† Annals of Nat. Hist. vol. i. p. 1. The connection of the words glas, glass, glastum, and vitrum, is very curious. Vitrum means glass, sea-green, and woad, and we have the same meanings in the three first-mentioned words. Perhaps the word glastum was invented by Cæsar.

could do so consistently, if *Nostoc* and *Chætophora* were associated with the simpler forms. The species are extremely numerous, though in general obscure; a few, however, are remarkable for their beauty, and none more so than *Petalonema alatum,* in which the investing tube is so broad, and the lines of growth so distinct, that, in conjunction with the beauty of the colouring, the characters seem to point to something much higher in the scale of vegetation. *Oscillatoriæ* occur in all parts of the world under some form or other; and though the greater part inhabit fresh water, damp shady spots, or rocks down which water trickles, they are by no means deficient in the sea, where perhaps they attain their greatest size. Numerous species affect thermal springs, and a very noble kind, of a deep red, forms thick woolly fleeces in the hotter parts of India, as in the hot valleys of the great Runjeet,

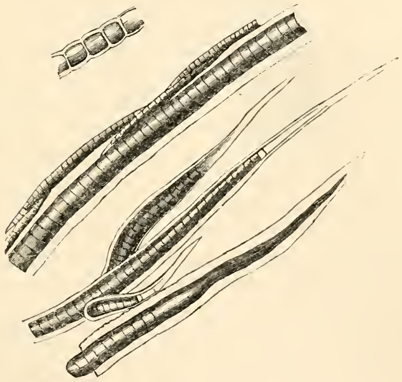

Fig. 35.

Erythronema Hookerianum, Berk.

Magnified from specimens received from Dr. Hooker, gathered in nullahs, at Fitcoree.

ascending up to the subalpine regions, which border the Himalayas. A few grow like Lichens on the trunks of trees, and

I have a beautiful species which has its seat on old bones in South Carolina. The most singular habit is, however, possessed by one genus, analogous to that of the larger floating Algæ. But instead of forming circumscribed patches, it spreads for many miles over the surface of the sea, according to the direction of the wind, in the form of a red brown scum, the little faggots of threads of which it is composed, resem-

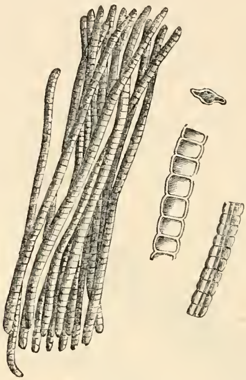

Fig. 36.

Trichodesmium erythræum, Ehr.

Magnified from specimens collected by Mr. Darwin, compared with Dr. Montagne's analysis in Ann. d. Sc. Nat., Sér. 3, vol. ii. tab. 10.

bling minute fragments of chopped hay. It is even conjectured that the Red Sea may have acquired its denomination from this little Alga, which is very prevalent there, and forms a conspicuous object to all observing navigators.* It is curious that, in some instances, this scum emits a disagreeable pungent smell, affecting strongly the mucous membrane, and thereby causing temporary inflammation of the eyes and troublesome sneezing. The property of emitting an unpleasant odour is

* One of the earliest notices of this phenomenon is in Osbeck's Voyage.

not, however, confined to the genus *Trichodesmium;* some of the common species of *Oscillatoria* emit a strong odour of sulphuretted hydrogen, similar to that of the common Chara, insomuch that on one occasion I was obliged to have a water tub scraped, to remove the Algæ which had taken possession of its sides to such an extent as to be extremely disagreeable, and to cause sometimes severe headache.

117. The true *Oscillatoriæ*, forming a slimy stratum, which though thin at first gradually acquires a certain degree of thickness, so as to peel off in flakes, in consequence of the decay of the older growths. They have long been celebrated for the oscillating motion of the threads. It is possible that this motion may, in part, be due to the propagation of the threads by division and ultimate separation of the inclosing membrane, to which also their radiation from a common centre, when a small portion is placed on a piece of moistened paper, may be attributable. But, besides this, many species possess, at the extremity, a tuft of delicate cilia similar to those which occur in *Anabaina*, and which, like those on the spores of *Œdogonium*, are capable of communicating motion to the body on which they are developed. However this may be, it is quite certain that these organisms do not belong to the animal kingdom, the whole history of their development, and their evident connection with undoubted vegetables, making such a notion altogether untenable. A few of the species, like the *Nostochineæ*, impart a peculiar tint to large masses of water, according as their prevalent colour is green or purple. Phenomena of this kind have been observed in Switzerland and Scotland.*

118. It was once supposed that their endochromes were of a totally different nature from those of *Confervæ*, consisting merely of circular discs, filling up a common tube, and finally expelled from it. There is, however, no doubt that they are of the same nature as in other allied Algæ; that each is contained in a distinct sac; and that multiplication takes place in the

* See *Lyngbya Prolifica*, t. 303; and De Candolle, in Mémoires de la Soc. Phys., &c., de Genève, vol. iii.

same way by division of the endochrome, and the formation of a new membrane round each division. It may be true, that in some instances the sac may be absorbed, and the discs set free, but that is a totally different question. The real distinctive character resides rather in their narrowness, in consequence of which they appear annular. This character, however, loses its preciseness, in some cases, either by the narrowness of the endochromes in true *Confervæ*, or their elongation in *Oscillatoriæ*.

119. Generic characters are afforded by the different conditions of the two principal elements of which they are composed, viz., the external common tube, and the endochromes. The two are seldom luxuriant at the same time, and the different conditions exhibited by both are often very curious. The simplest case, perhaps, is that of *Oscillatoria*, which consists of straight or slightly curved chains of endochromes, contained in a common tube. When disposed to divide, two of the endochromes, or the two parts arising from one original endochrome, recede from each other; the outer tube contracts at the point of division, separates there, and thus gives rise to two distinct organisms. In some cases, however, the outer tube is of a less yielding substance, and, in consequence, the divided parts retain their place in the tube, which dilates in proportion as these new threads are again divided; and thus we have a common tube containing a number of threads, or, in other words, we have the genus *Microcoleus*. The threads remain in this case perfectly distinct, but frequently the divided ends slip or grow over each other, sometimes becoming attenuated, and thus a sort of spurious ramification takes place, and finally, in some cases, union between the two portions, as in *Cœnocoleus*. Sometimes, again, it happens that a connecting cell is formed, as in the Nostochine genus *Sphærozyga*. Now if the thread is disunited below this cell, the next endochrome becomes elongated, and the original thread is thus continued beyond the fractured portion, being more or less diverted from its course, and we have thus the peculiar structure of *Calothrix*. In some cases, the terminal globose or elliptic cell is formed after division, and sometimes

division takes place in the lower parts, at a connecting cell, while, in the upper parts, there is merely a dislocation, and sliding of the two divisions over each other. In some cases, as in *Scytonema*, the two portions grow equally at the divided ends, penetrate the outer tube together, and thus form the binate ramification, which is so peculiar in that genus; if, however, the thread of endochromes protrudes without rupture, a large loop appears at the side, instead of the twin branches, and if this structure is repeated, we have a reticulate frond of greater or less regularity, according as the increase has taken place upon one system only, or a combination of several. The greater or less tenacity of the outer tube has influenced, in some measure, the characters of the vegetable, but this sometimes goes much farther; the tube itself consists often of distinct coats, the number of which increases upwards. These sometimes originate with such regularity as to produce the beautiful striated appearance, which is so remarkable in *Petalonema;* but in cases where there is not so much regularity, the different coats are often distinctly marked, and, in some instances, where the chain of endochromes extends beyond the tube, the edge of the tough compound tube is lacerated, and curled back, so as to present a series of frills, which are complicated in consequence of the divisions of the chain adhering to each other, and forming more or less regular ramifications. In *Desmonema Dillwynii*, which has, in some parts of the frond, large connecting cells, and in others simply the ends of the threads attenuated and applied to each other, like the ends of an ill-set bone, the outer tube is sprinkled with obtuse linear bodies which, perhaps, are indications of roots. Branched anastomosing root-like articulated threads are freely given off from the tube of *Rhizonema interruptum*, which is, moreover, composed of cells, a fact attended by great difficulties, though not without parallel in the spores of certain Fungi. The cells do not seem at all conformable with the endochromes, and their formation is possibly entirely independent of them. That the tube should sometimes be marked with a spiral line, is far less surprising. *Schizogonium* approaches very near to Ulva; and the species, such as

S. calophyllum, if not all, belong more properly to the same group. If the genus *Ulothrix* belongs to this division, of which I have no doubt, the endochromes are sometimes resolved into a multitude of zoospores, and I believe this to hold good with *Lyngbya speciosa*, and *L. Carmichaeliana*. In the genus *Seirosiphon*, bodies are produced resembling *Glœocapsa*, which are clearly reproductive. It is probable too, that in some cases the connecting cells, which are filled with pure green endochrome, like those of *Sphœrozyga*, are reproductive.*

120. It may, however, perhaps be doubted whether any of the species of *Seirosiphon*, beautiful as they are, are autonomous. At any rate, their mode of growth and ramification are totally

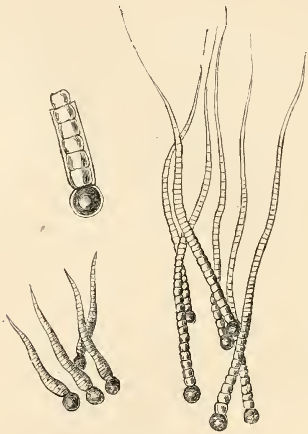

Fig. 37.

Threads of *Rivularia nitida*, magnified with their connecting cells, from specimens gathered at Torquay.

different from those of other *Oscillatoriœ*. It is a single endochrome, in fact, which bursts through the investing tube,

* Unger says, that *Nostoc Sphœricum* is multiplied by the connecting cells. Act. Nov., vol. 16, P. ii. p. 546, tab. xxxix.

and constitutes a branch, a character by which the species are at once known from *Scytonema.*

121. We come now to the compound gelatinous forms. And here we have jelly of very different tenacity in different species. In *Dasyglœa* the masses are so slippery, that they can scarcely be handled; the common tube of each chain of endochromes being exceedingly thick and very tender. In some of the marine species, however, the jelly is so firm that thin slices can readily be obtained for microscopical examination, while *Rivularia nitida* is often so tender as to make a clean section almost impossible. The great peculiarity of *Rivularia* and its allies consists in the mode of branching, which arises from the alternate turning aside at tolerably regular intervals of a connecting cell. In consequence of this singular mode of origin, the branching is oblique, the main thread being always diverted from a straight course at the point at which the new branch is set on. Many of the species of *Rivularia,* in consequence of the peculiar branching, are very interesting objects under the microscope. They occur on the stumps of aquatic plants, on rocks in rapid streams, sometimes where they are exposed constantly to the force of cataracts, and in calcareous water, in consequence of which crystals of carbonate of lime are deposited in their substance; other species again grow on exposed rocks, subject to the constant wash of the waves, while one of the most beautiful (*Rivularia nitida*) occurs amidst other Algæ on the flat rocks which are exposed at low tides, though not in every state of the moon. A very pretty species floats on the surface of fresh water lakes, like minute green stars.

122. *Oscillatoriæ* occur in every part of the world, and are especially common in temperate regions, though by no means confined to them, and often in waters of considerable temperature. The curious *Rhizonema interruptum* has been found in Ceylon, by Mr. Thwaites, exactly resembling the specimens which he has figured so beautifully in the Supplement to English Botany, t. 2954. The *Rivulariæ* appear to be confined to the northern regions. I do not find any trace of them amongst the Indian Algæ, nor does any

species occur in the Antarctic Flora. Their size is in general so small as to make it improbable that they can be of any practical utility.

9. CONJUGATÆ, *Berk.*

Threads articulate; their endochrome generally assuming some definite arrangement, often forming one or more spirals. Spores or zoospores formed by the union of two endochromes in the same or contiguous threads, or from the division of a single primary endochrome.

123. Perhaps among all the Chlorosperms there are none more worthy of attention, whether as regards their component cells, or their mode of fructification. The first exhibit many phenomena illustrative of cellular formation in general, and its transformation into spiral vessels, while the latter opens a wide field for investigation in the variety of phases it assumes. The threads of these plants in their primary condition consist of a row of cells, very much as in ordinary *Confervæ.* The endochrome, however, shows more evident traces of organization, even in the simpler cases exhibiting at least larger granules disposed in rows; but in others, one or more broad spiral bands, with larger granules at different portions of their course, or binary masses often assuming a stellate form. In some cases a large cytoblast is distinctly visible, from whence proceed delicate rays, exactly like those from the nascent spores of *Anthoceros.** These cytoblasts have sometimes a second nucleus; sometimes they are positively central, sometimes attached to the walls, and their function is as obscure as in higher plants. In many instances, the inner membrane of each cell is singularly depressed at either end by a sort of introsusception, and sometimes it protrudes into the neighbouring cell (Fig. 38, *b.*); and where this is the case the main thread is often disarticulated, and the liberated joint forms the ground-work of a new thread, as in the *Oscillatoriæ.* The external coat, which in this instance gives way so easily, varies greatly in consistency in different species. Sometimes it is simply membranous; sometimes it is gelatinous, and occasionally very thick, varying in different

* Mohl. in Linn., vol. xiii. tab. v.

parts of the same thread. In one Indian species the jelly is so abundant that the dry specimens present a sort of net-work with compound threads. Unfortunately I have no information as to its condition when fresh. The most singular point, however, in these plants, is the mode of formation of the spores. These arise from the intermixture of two neighbouring endochromes, or from the division of one primitive endochrome into two, and very rarely indeed in several successive articulations. In this latter case, the divided portion of the endochrome, which did not bear a spore, swells, increases in length, is itself divided, and the posterior half becomes fertile, and the process may be repeated till a chain of spores is formed.* The endochrome in the fertile half-cell, whether mixed with

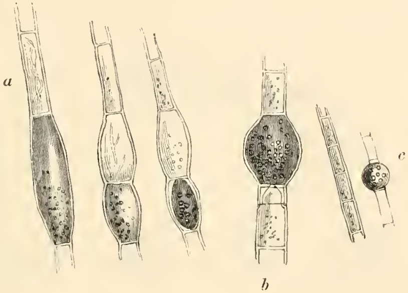

Fig. 38.

a. Threads of *Œdogonium concatenatum*, Hass., showing the origin of the spore from the division of one of the articulations into two cells.

b. Thread of *Œdogonium crassum*, showing the protrusion of the inner membrane before disarticulation.

c. Threads of *Œdogonium hexagonum.*

All magnified from specimens in my herbarium.

that of the neighbouring cell or not, contracts into a globular or elliptic mass, acquires a distinct envelope, most probably after impregnation, and thus forms a spore. In some instances these spores are perfectly quiescent, but in others they have

* Thwaites in Ann. of Nat. Hist., vol. xvii. p. 333.

ciliated appendages (Fig. 26, *c.*) at one extremity, by means of which they move about with an apparently spontaneous motion. Whether quiescent or active, the spores, after a time, become attached at one end by two or three root-like processes, the endochrome divides, and new threads are formed. Derbès describes these spores as sometimes breaking up into numberless minute zoopores, and this appears to be the case in *Œ. pulchellum*, as communicated to me by Mr. Thwaites. The microgonidia, which are supposed to be true antheridia, have already been described and figured. (Fig. 26, *a.*) There is, however, still ample room for fresh investigation.

124. In many cases it is not merely the division of a fertile cell, or the junction of two contiguous endochromes, which gives rise to the spore, but that of the endochromes of two distinct threads, parallel to each other and connected by

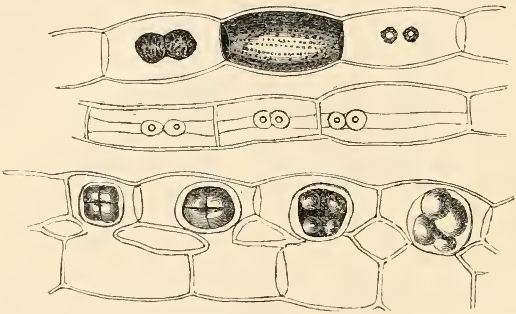

Fig. 39.

Threads of *Thwaitesia Duriæi*, Mont., magnified from sketches communicated to me by Dr. Montagne.

means of little processes mutually put forth from their sides. In those cases the spores are frequently formed in the connecting tube, the two dissepiments being previously absorbed. In some cases, however, though the lateral tube is protruded, union does not take place, and the spore is formed in the protruded tube. Union does not, however, always take place, even in conjugating threads, by the formation of connecting tubes. In the genus *Mougeotia,* and some others, the threads become geniculate, and unite at the two bends, sometimes indeed with, but often without, connecting tubes, and according to circumstances the spore is globose, elliptic, or subquadrate. In *Thwaitesia,* (Fig. 39,) and in at least one other genus, the endochrome of the spores is divided longitudinally and transversely, and so four new spores arise.

125. Should it prove true that the spores are in many cases eventually resolved into myriads of zoospores, we shall have merely the same process which takes place in *Ulothrix.* The bodies which produce the zoospores are a distinct transformation of the endochrome, and it is very probable that such bodies, in their first condition, may be capable of propagating the plant, while, under other circumstances, their endochrome may undergo a further change and produce zoospores.

126. The species are extremely numerous, and exhibit very great variety in the nature of the endochromes and the disposition of the spores. A curious series of circular folds is often formed in the outer tube where the spores are produced, arising apparently from its growing faster than the contained sac. This is conspicuous in many conjugate species, but nowhere more so than in the genus *Œdogonium,** which certainly ought to be placed in the same series. In this latter genus there is a singular tendency in the green spores to pass into a bright red or scarlet, which is not without its parallel in earlier and simpler species, as for instance in *Protococcus.* The endochrome of the spores of *Zygnema* is apparently uniform, but Pringsheim † has found that, after they have been steeped for some time in oil, there are traces of a spiral structure, a

* In *Œdogonium capillare,* Kütz., the granules of the endochrome in certain stages assume a spiral arrangement, and larger granules are connected with smaller. Ultimately the several spiral threads cross, and form a network. Many instances of reticulate endochrome, by the formation of vacuoles, occur in different groups, as *Ectocarpus, Hydrodictyon,* &c. See Kützing, Phyc. Gen. tab. ii. 12; Derbès and Solier, l.c. tab. 5 ; Cohn Untersuchungen, tab. 19, &c.

† Flora, 1852, tab. v.

fact which soon attracts attention in germination by the occurrence, in a spiral direction, of linear tracts free from endochrome, which soon unite with each other so as to be continuous, and to divide the endochrome into a distinct spiral band.

127. The species are, with scarcely an exception, inhabitants of fresh water, and are probably widely distributed. Numerous species occur in the collections of Dr. Hooker and Dr. Thomson, both in the more northern and southern Himalayas, but they descend into the lower parts of India, as at Bijnour or in Silhet. The curious genus *Thwaitesia* first occurred in Algiers; but there is a species also in the Soane river, in which not only are there tetraspores, but the endochrome is in some instances resolved into active molecules. The spores are formed indifferently in the joints and conjugating tubes. The most striking feature, indeed, amongst the fresh water Algæ of India, is the prevalence of *Zygnema* and *Tyndaridea*, which occur under a variety of forms, and sometimes with very thick gelatinous coats, to which a parallel is afforded by the beautiful species *Tyndaridea anomala*, figured by Mr. Ralfs, Eng. Bot., Supp. t. 2899. The genus *Zygnema* ascends as high as 15,000 feet in the Himalayas, while *Oscillatoria*, *Cœnocoleus*, and *Conferva* reach 17,000, or even 18,000 feet. One very interesting form mentioned above, either belonging to the genus *Zygnema*, or possibly constituting a distinct genus, occurs in streams at 5,000 feet in Sikkim, consisting of highly gelatinous threads of the normal structure of *Zygnema*, but forming a reticulate mass. The threads adhere to each other laterally, and the articulations are very long, and contain only a single spiral band. Amongst these are the normal threads of some *Tyndaridea*. They do not appear to be common in the southern hemisphere. No species occurs in the Flora Antarctica; *Tyndaridea anomala*, and one other species only, have been found in New Zealand. Montagne's *Sylloge*, in addition to *Thwaitesia*, contains but a single extra-European species from Cayenne; besides which, there is scarcely more than a trace of them in South America.

128. A most singular Alga occurred amongst the Himalayan

collections, which requires especial notice, as it is the only instance I know, in this group, of the peculiar structure which it exhibits. The threads at first are like those of an ordinary *Tyndaridea*, but after a time little swellings occur on their sides in which a distinct endochrome is formed, extending backwards into the parent endochrome, separated from it by a well-defined membrane, and producing either by repeated pullulation a compound mass like that of *Calothrix*, or simply giving rise to a forked thread. In the latter case there is no external swelling, but a lateral endochrome is formed, which, as it grows, makes

Fig. 40.

Threads of *Cladozygia Thomsoni*, Berk. in various stages of growth, magnified.

its way through an aperture whose sides are regularly inflected. I have given to this curious production the name of *Cladozygia Thomsoni*.

10. BULBOCHÆTEÆ, *Berk.*

Threads articulate, branched, fertile branchlets, bulb-shaped,

* An appearance is figured in *Cladophora fracta*, by Kützing, Phycologia, tab. 11, fig. 5, which is of the same nature ; and something approaching it in *Œdogonium capillare*, l. c. tab. 12, fig. 2, i., where the lateral branch sends a root down into the parent endochrome.

surmounted by a long hair-like point. Endochrome apparently impregnated by bodies produced in little antheridia seated on the walls of the fertile cells, dividing at length into four ovate zoospores.

129. This section consists of a single genus only, unless *Coleochæte* should prove closely allied, containing three or four species; of which one occurs in Cayenne. It is usually associated with *Chætophora*. The ramification of the threads is not unlike that of some *Cladophora*, but a certain number of the cells in the lateral branchlets end in a very long colourless hair, while the base assumes the form of a little bulb. The endochrome of this bulb soon becomes compact, and at the same time little processes, like those of *Œdogonium*, are developed on the surface (Fig. 26 *b*), and the wall itself becomes fissured, apparently to admit the contents of the microgonidia. The endochromes then acquire a membrane, and appear to be perfect spores. After a rest, however, of many weeks, the endochrome elongates and is divided into four ovate zoospores, with a tuft of cilia at one extremity. The species grow in fresh water, and one discovered by Mr. Thwaites is a parasite upon one of the larger species. They appear, as far as is known at present, to be confined to the northern hemisphere; they are evidently allied to *Œdogonium*, but their habit, the formation and metamorphosis of their spores, and other points, indicate their separation.

11. Siphoneæ, *Grev.*

Threads rooting, consisting of a single cell, often much branched, and sometimes traversed by filiform processes, arising from the walls, free or invested with calcareous matter. Propagation by minute zoospores, by large quiescent spores, or by large active spores clothed with cilia.

130. This tribe might be divided conveniently into several sections, but the forms which it comprises are so closely united, that it seems better not to divide too nicely. The essential characters consist in the plant, however complicated, being composed of a single cell, only variously modified.

131. The most simple forms are displayed by those minute Algæ, more or less resembling microgonidia, which have been

illustrated by Nägeli, Kützing, and Braun. Several have been detected in the act of forming zoospores. Their size is always minute, and they are so like microgonidia, as to suggest a thought that they may be connected with some larger Algæ. I have never had an opportunity of studying them in their natural condition, and therefore cannot speak confidently of their affinities. They are, possibly, as nearly related to *Confervaceæ* as to *Siphoneæ*, but technically they agree better with the latter. They do not seem to me to be in the least degree related to *Palmelleæ*, and the transition from *Codiolum gregarium*, Br.,* to *Codium amphibium*, is so easy, that I have little hesitation in the matter. Perhaps, however, *Botrydium* (Fig. 24) is still nearer.† There has already been an indication of abortive rootlets in the former. In *Botrydium*, from its mode of growth, a still further development is necessary, and thus one of the peculiar features of the greater part of *Siphoneæ* is attained. *Vaucheria* (Fig. 22) differs little from *Botrydium* (Fig. 24), except in the elongation of the subglobose cell, into a simple or branched thread. *Vaucheriæ* are mostly of a bright green, abound in pools, or on the damp soil of fields and gardens, and form large tufts on mud, whether impregnated with salt or fresh water, which they tend to hold together by their numerous filaments. They are by no means confined to the northern hemisphere,

* Braun, Alg. Unicell. genera nova, tab. 1. *Codiolum gregarium* grows on beams moistened by the spray, while *Codium amphibium* affects turf-banks at high water mark.

† The genus *Chytridium*, Braun, which is propagated by zoospores, is referred, in Bot. Zeit. 1855, p. 678, by Bail, to Fungi, and Cohn seems to consider it closely allied (Untersuch. tab. 16). The cells are, in fact, truly parasitic, and send down a sort of mycelium into the cells of the Algæ or Infusoria, on which they grow, rapidly exhausting their endochrome. They are parasitic, for instance, on species of *Euglena*, *Hydrodictyon*, and *Closterium*. If this notion is well founded, we have a direct transition, though other of these productions are undoubted Algæ, through *Achlya* to *Mucor*. The plant figured by Cienkowski, in Bot. Zeit. 1855, tab. xi. as *Protococcus botryoides*, is probably a *Botrydium*, and if so, that genus produces large resting spores and minute swarming spores. It is said to grow with *Botrydium (Hydrogastrum granulatum)*, and is certainly no *Protococcus*.

but they retain their habit in New Zealand, and, probably, in many other southern climes. Their fruit is either lateral or terminal, often in pairs, accompanied by curved antheridia (Fig. 25), which have already been described, p. 89. The species are mostly determined by the situation and character of the fruit, which appears under many modifications. In *Vaucheria clavata*, the spores, instead of being quiescent, are clothed with minute cilia, like those on the mucous membrane, and are, in consequence, endowed with active motion. Whether, in this case, there are also spermatozoids, is still a question. In many genera, however, the fruit consists of far smaller zoospores, with delicate flagelliform appendages. The marine genus *Bryopsis* is remarkable for the regular arrangement of the divisions of the component cell. The species are mostly parasites on other Algæ, and produce innumerable minute zoospores, by which they are propagated. Cysts also are occasionally produced, but it does not appear that they ever have true spores like those of *Vaucheria*.

132. The compound species abound on sandy coasts, more rarely on rocks,* or in deep water, affecting generally warm climates, but the genus *Codium* ascends to high latitudes, and appears under four different forms on our own coasts, in three instances inhabiting deep water, or rocks never uncovered except at spring tides, and in the fourth, occupying turfy banks, exposed to the spray. The zoospores are large and strongly granulated with a pellucid apex, and two delicate appendages.

133. Of those green Algæ which are masked by calcareous matter, there are two series distinguished by their monosiphonous or polysiphonous stems. Of the latter, I have already spoken under *Confervaceæ*, under the impression that they are really more allied to the articulate than the inarticulate Algæ. It is clear, however, that all is not yet known about

* In the Red Sea, some of the species root into madrepores, others grow on rocks, and sometimes, where these hang over, the fronds are directed downwards. Their tips, as observed first by M. Botta, are often yellow, while the base is green, a fact which may be verified in any herbarium.

Acetabularia, for the elliptic spores figured by Kützing, in the threads which form the orbicular disc, have only been observed in dried specimens, and we are ignorant of the nature of the series of apertures on the surface of the internal circle of cells. Suchcharacters are, however, not more incompatible with *Confervaceæ* than with *Siphoneæ*. In the more compound species, a

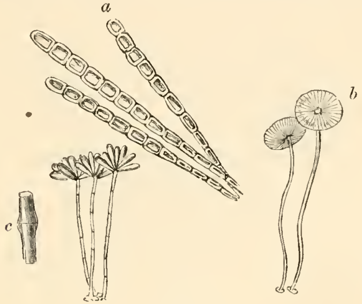

Fig 41.

a. Conferva clavata, var. Darwinii, *Hook.*, from small specimens collected by Mr. Darwin, nat. size.

b. Acetabularia mediterranea, nat. size, from specimens communicated by Nägeli.

c. Polyphysa penicillus, nat. size, from specimens sent from King George's Sound, by Dr. Harvey, with a portion of the stem magnified.

multitude of forms are produced, simulating *Cacti*, reticulated corals, flabelliform corallines, &c., which are either beautiful in themselves, or in their structure.* The genus *Halimeda* (Fig. 42) has been well illustrated by Messrs. Derbès and Solier, and it is one of those productions which can be studied with satisfaction only in their native locality. The obovate lobes, of which the plant is composed, are traversed by an immense number of branched threads, which, through the whole of their course, and throughout their ramifications, are without septa.

* The best way of examining these, is by applying hydrochloric acid, which changes the carbonate of lime into the soluble chloride of calcium.

The branchlets form a close fastigiate mass, which unite above, so as to make, by their confluence, a cellular envelope with irregularly hexagonal cells. One or more new tufts are formed at the apex, which again ramify, and thus the whole cactus-like frond is generated (Fig. 42). In this state, however, the plant is void of fructification, which does not, indeed, seem to be produced very generally. The fructifying individuals pre-

Fig. 42.

Halimeda opuntia, Lamx.

Nat. size, and a portion of the threads magnified. From Mediterranean specimens communicated by Nägeli. Specimens from Central America, collected by Mr. Hinds, do not differ.

sent little Confervoid tufts, divided repeatedly above, and terminating in subglobose fastigiate branchlets. The endochrome of these gradually becomes organised, and produces innumerable active molecules, which, doubtless, are capable of propagating the plant, as in allied genera, though their development has not at present been observed. *Cymopolia* appears to have fruit not very dissimilar from *Halimeda*, as far as may be judged from Kützing's figures, taken from dried specimens. The lateral threads which project from the surface, bear an umbel of three or four branches, each terminating in a swelling filled with granular matter, while in their centre is a shorter branch, supporting a large elliptic sac. Besides these threads, the terminal joints of the frond, as in *Halimeda,* have a tuft of filaments, which, like those of *Acetabularia,* are decidedly articulate, and indicate, therefore, a different alliance; these do not, apparently, bear any fruit. Other calcareous species have been described, resembling in structure *Codium* and *Caulerpa,* or approximating higher groups, but they do not throw much light upon the nature of the fruit, and examination in their native locality would, probably, show that all are not intimately related. *Dasycladus* has been illustrated in Derbès and Solier's memoirs, and is also figured by Kützing, and seems rather a compound *Conferva* than *Vaucheria.* In the genus *Flabellaria,* globose cysts are produced here and there upon the component threads, near the edges of the fan-like expansions, and it is probable that the contents of these are resolved into zoospores, in the same manner as in so many other Algæ.

134. Finally, the numerous species of *Caulerpa* and its subgenera deserve notice, from the beauty of their form, and the singularity of their structure. They are strictly unicellular, however varied the external appearance assumed by the plants may be. The most singular point about them is, that from their walls complicated branches are sent out into the mass of green granules, which fills the frond, ramifying in every direction, and affording, doubtless, great support against disturbing external agents. The chemical character of these threads requires to be studied. They are, in fact, extremely anomalous productions, and it appears that Decaisne is quite right in his views, as to their origin. The cell-walls from which they arise are very thick, and in some instances cartilaginous, and Decaisne* has figured concentric rings in their lining substance, indicative of successive growth. He remarks, moreover, that this is not the only case in which the matter, with which the threads in the inside of the frond are bathed, contains granules. The threads in some of the cases which he mentions, as *Splachnidium, Champia,* &c., are of course of a very different nature from the processes just

* Decaisne, Plantes de l'Arabie Heureuse, tab. 6, B. 5. Näg. Zeits. vol. i. tab. 3.

mentioned, which are not at all cellular. Many of the granules, according to his observations, are pure starch grains. The genus did not come under the notice of the authors of the memoirs so often mentioned, illustrative of the zoospores of Algæ. The best information we have on the subject, is in a paper by Dr. Montagne,* who had not, however, the advantage of examining living specimens. *Cladothele*, a very curious marine Alga from the Falkland Isles, considered by Hooker and Harvey allied to *Codium*, appears to me very doubtful as to its affinities. It is a mass of cells, which alone forbids its approximation; nor does there seem to be any nearly allied genus amongst the calcareous Algæ referred to *Confervaceæ*. The point of attachment, moreover, is wanting, and it is, therefore, uncertain whether it has a mass of rooting fibres. The discovery of the fruit may possibly unravel its true affinities. I am half inclined to think that it is a highly compound subcalcareous form of the next division, *Ulvaceæ*.

135. *Vaucheria* extends as far south as Kerguelen's Land, where *Codium* also appears, as it does far to the north, the species in both cases, so widely diffused, being *C. tomentosum*, which occupies also very numerous intermediate stations, while both that and *Codium adhærens* occur in New Zealand. The latter is a native of the Cape and Mauritius, as well as of Europe. *Caulerpa*, which in the northern hemisphere is strictly an inhabitant of the warmer districts, extends in the south under five species to New Zealand. *Bryopsis* also occurs in New Zealand, and as far south as the Falkland Islands, and the seas about Cape Horn. The numerous species of *Caulerpa* afford almost the whole sustenance of turtles on many coasts, and other species furnish nutriment to a host of smaller animals.

12. Ulvaceæ, *Ag.*

Cells divided vertically and horizontally, so as to make a frondlike or tubular membrane. Propagation by zoospores furnished with flagelliform cilia.

* Comptes rendus 26 février, 1838, and Ann. d. Sc. Nat. sér. 2, vol. 9, tab. 6.

136. We have already had some approach to a simple frond-like expansion in the genus *Schizogonium*. Without, however, adopting the notions adduced by Kützing, in his various works, but more especially in his prize essay, on the origination of these leaf-like expansions from *Confervæ*, we have in the genera *Prasiola* and *Bangia*, almost Confervoid threads, the one representing the green, the other the purple series. If the threads in these genera are laterally expanded by repeated vertical division of the endochromes, it is evident that we shall at once have a frond composed of one or more layers of cells, not only elongated, but indefinitely expanded. In other cases, instead of a flat expanded frond, a sac is formed, consisting of a similar membrane, but closed all round, either for a season only, or during the whole period of life, and branches of one or many orders are formed from it by a process not dissimilar, in all probability, from that by which the first sac was generated from the young spore. It is easy to conceive a scheme for such a formation, but I am not aware that the mode of growth has actually been followed out through every stage.* The increase in this order very frequently takes place by the quaternate division of the endochromes, especially in the fresh water species, and the frond often progresses for a long time without any appearance of fruit. This, however, is formed by an organisation of the granular matter of the endochromes, and the resultant zoospores have two flagelliform appendages. In *Phycoseris gigantea*, there are frequently four, as also in *Ulva bullosa*. The biciliate spores, however, do not arise precisely from the same tissue as the quadriciliate, but from one consisting of smaller cells, and are themselves smaller. The plants also which produce them have a yellow tint.† The young plants, on their first appearance, are in all respects simple *Confervæ*, but the apical cells soon divide, and a plane or saccate frond is formed.

137. M. Thuret informs us that he has seen the biciliate spores germinate as well as the quadriciliate, which is certainly indicative of identity of function. It is, however, right to men-

* See, however, Nägeli neu. Algensyst., tab. 1, fig. 55—58.

† Thuret, l. c.

tion, that Robin asserts that in *Ulva Lactuca* two sporiform bodies of different functions are generated, one of which germinates, and the other, which is quadriciliate, never does so. He believes, moreover, that these last are truly spermatozoids. In such minute bodies it is always difficult to speak with absolute precision, and even giving full credit to the observation of M. Thuret, that the biciliate bodies do sometimes germinate, it does not follow that Robin's observations are devoid of truth. It is certain, at least, in some of the Algæ which follow, that the ciliate bodies are not capable of germination, but truly of the nature of spermatozoids. The Antarctic genus, *Mastodia*, does not belong, properly, to this group, but will be noticed hereafter among the gelatinous Lichens. *Stigonema* also belongs to the same category.

138. These Algæ are distributed over the whole surface of the globe, but they abound principally in colder latitudes. *Enteromorpha intestinalis* and *Bangia atropurpurea* grow indifferently in fresh and salt water. The green species are occasionally eaten, but it is *Porphyra*, more especially, which supplies on rocky coasts, where there is not sand to make the fronds gritty, the laver of commerce. The best way of preparing this vegetable or condiment, which is extremely wholesome, is to heat it thoroughly with a little strong gravy or broth, adding, before it is served on toast, a small quantity of butter and lemon juice. *Enteromorpha intestinalis* is used in Japan, when dried, for soup.

139. Some Algæ, as *Tetraspora*, in which the gelatinous element predominates, usually referred to *Ulvaceæ*, belong more properly to *Palmelleæ*, in which highly compound fronds are presented by *Hydrurus*. The genus *Hormospora*, which occurs both in salt and fresh water, is a filamentous Palmelloid. In *H. ramosa*, Harv. Phyc. Brit. t. 213, the threads, which are parasitic, on *Cladophora fracta*, are irregularly branched. One of the most curious Algæ, perhaps, on record, is *Psichohormium*, described by Itzigsohn in Flora, 1854, p. 17, and accompanied by a figure. It is placed by Kützing next to *Conferva*, but its relation is doubtful. The articulations are obscure, and it is, possibly,

more nearly allied to *Hormospora*. The singularity consists in the repeated division of the endochrome, till we have a tube constricted at regular intervals, each division containing a glæocapsoid mass, so as to present some similarity to a *Seirosiphon*. Whatever its true affinities may be, it is too singular to allow of its being passed without notice.

140. It may be well to add a few words here on *Oprhydium versatile*, Ehrb., the component animals in the mass of which have so great a resemblance to the zoospores of some Algæ. The masses are an inch or more in diameter, and resemble closely those of *Rivularia pruniformis*. The individual animals are all supported on delicate hyaline threads, which are altogether neglected in Ehrenberg's figure. They have two sets of cilia at the apex, much after the manner of the zoospores of *Œdogonium*, but the whole of the apex is retractile at will, insomuch that the ciliatory motion is often discernible in the centre. This would not take place without muscles. The contents of the cells closely resemble the chlorophyll of *Vaucheria*, and deserve a comparative study. I do not find that the cell wall is blue with iodine and sulphuric acid. The green granules, under the same treatment, undergo the same changes as those of *Confervæ* or *Vaucheria*. In Poggendorf's Annalen der Phys. and Chem., 1855, there is a notice by Salm-Horstmar, on the green matter of *Infusoria*. It is, however, uncertain what species are meant. If *Diatomaceæ*, the case is not one in point. According to him, it is not of the nature of wax, and no true chlorophyll. See Bot. Zeit., 1855, p. 596.

141. Before I quit the subject of *Chlorosperms* altogether, I shall add a few words respecting the variations to which they are subject. By variations, I do not mean the changes which may take place in different stages of growth, but those changes which are dependent on other causes, whether constitutional or external. When a *Desmidiad* is propagated by a spore, the spores are so totally different in form and sculpture, that the plants first formed by them must be very different from ordinary individuals, as the growth from spores and cells is conducted on the same principle. The first plant will

consist of the two halves of the spore, and two new half cells, which bear no resemblance to the spore. In *Diatomads,* again, the conjugating frustules which have arisen from repeated cell division, are generally of very different sizes, as are also the resultant frustules. In some species it seems matter of necessity that the frustules which arise from repeated cell division should become gradually smaller; and in others, whether necessary or no, it is a fact that they do decrease in size, and the effect of the conjugation is to restore at length the normal condition.* These differences should, therefore, make us cautious in the proposition of new species. They are, however, differences connected with the nature of these organisms, and are not to be considered as real variations. Real variations do, indeed, take place in the shape of the fronds or frustules, the degree of their cohesion, the number of striæ, and other points which require to be taken carefully into consideration. In *Palmelleæ,* the degree in which division takes place, the number of the investing sheaths of mucus, and the forms of the endochromes, vary so much, that species ought not to be described on slight grounds, depending on imperfect observations, which a glance at the microscope may overthrow to-morrow.

142. When we come to the articulated Algæ, amongst which the distinctions of species are often slight, an increased degree of caution is requisite. A very short acquaintance is sufficient to show the immense difference of diameter which may exist in threads of the same mass, and in the same threads the proportions of length and breadth in the articulations are quite as variable. Species, therefore, evidently of the most close affinity cannot be safely separated from mere consideration of relative proportion, without any other characters. Even the branching of the threads is not sufficient, or the mode of branching. *Cladophora glomerata* assumes a multitude of forms which it would be rash in the extreme to separate, and it may be safely affirmed that of published species of *Cladophora* and *Conferva,* at least one half will ultimately be reduced. Where

* See Carter, in Ann. of Nat. Hist., vol. xvii., p. 1, where many figures are given of conjugating *Diatomaceæ.*

Confervæ are exposed to drought, they sometimes throw down roots from their joints in search of moisture, a circumstance which must be taken into account in the estimation of species. In *Lyngbya muralis*, the threads often anastomose, producing a very curious and puzzling appearance. In the *Conjugatæ* the threads and their articulations are equally variable, but then there are differences in the disposition of the endochrome, and the formation of the spores, which afford good characters, provided every variation of position and form be not considered specific. In *Anabaina* and allied genera, the number and disposition of the fertile cells will not afford safe characters, nor will mere microscopic measurement, which is often deceptive, and should be always taken with considerable latitude amongst *Oscillatoriæ*. The zoospores even of the articulated Algæ are not absolutely constant. Monstrous forms occur in the small zoospores of *Cladophora* and the large ones of *Œdogonium*.* Characters like those in Hassal's Fresh water Algæ, dependent simply on comparative size, are altogether inadmissible.

143. Where plants, as many *Vaucheriæ*, grow under very different circumstances, being sometimes quite dry, sometimes covered with water, and that of various depth, the difference of length and thickness and of the masses formed by the threads will be very great. I have figured in the supplement to Eng. Bot. tab. 2841, the aquatic and terrestrial form of *V. cæspitosa*, Ag., which at first sight seem altogether different. Amongst the calcareous Algæ, considerable variety occurs in the shape of the frond in widely distributed species. *Halimeda opuntia*, for instance, varies greatly in form and size, and this is probably the case with many others. In *Caulerpa* it is quite certain that species have been needlessly multiplied. Decaisne has pointed out one or two cases in his Plants of Arabia. In *C. peltata*, Lamx., the same plant exhibits peltate branches, and the cylindrical adpressed branches of *C. Chemnitzia*, Lamx., while in *C. Freycinetii*, Ag., branches strongly toothed and even apiculate (*C. serru-*

* Cohn, l. c. tab. 20 Many other instances might be quoted.

lata, Ag. fil.), occur with others which are entire and cylindrical, flexuous and spiral. An inspection of any extensive collection of species from different localities will suggest many more examples.

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2. RHODOSPERMEÆ.—*Harv.*

FLORIDÉES, *Lamx.*, *Mont.*,—FLORIDEÆ, *Ag.*, *J. Ag. Endl.*—CHORISTOSPOREÆ, *Decaisne.*

ROSECOLOURED or purple, seldom inclining to green or brown. Fruit of two kinds; indefinite spores in distinct nuclei, either naked, in conceptacles, or inclosed in the substance of the plant; or tetraspores, external or immersed, scattered over the frond, or in distinct organs. *Antheridia* at present only partially observed.

144. It has been already stated that the genus *Chantransia*, leads directly to the blood-coloured Algæ, known under the name of Rhodosperms. The remark may, however, be extended to those associated genera as *Batrachospermum*, which produce the fruit in the form of moniliform threads, of which the upper joints are so many spores or sporesacs. The fruit of *Lemanea* is precisely of the same nature, and quite different from anything which has before occurred amongst the Chlorosperms. The anomalous genus *Chroolepus*, the threads of which in one state are orange, in another green, seems to oscillate between the two divisions of Chlorosperms and Rhodosperms. A few species only, of a comparatively simple structure, occupy the surface of barren rocks, occasionally sprinkled with the spray. *Callithamnion Rothii* is next in point of aerial habits, though periodically immersed, and to this succeeds a host of branched filiform species which avail themselves of almost any support which offers, provided it be immersed sufficiently long to sustain their vital energies. Whether any of the still simpler forms of Algæ really belong or not to this division, can only

be determined after a series of well-directed observations and experiments, instituted for the express determination of the point. It was before stated, how descending joints after the manner of roots form a cellular coating to the simple stem in the genus *Batrachospermum.* Precisely the same process takes place in *Callithamnion* (Fig. 26 *bis*), insomuch that a section at a given point which would have formerly shown a single cell, exhibits such a cell, surrounded by a circle of others. In many instances, however, as in *Polysiphonia,* the external cells are from the first an essential part of the plant, and from this the transition is easy to such genera as *Rytiphlœa* and *Ceramium,* and from thence to the most complicated fronds. Others, again, are formed after the fashion of *Ulvæ,* by a simple expansion of a frond, consisting of one or two layers of cells. The accession of veins and ribs gives additional thickness, and we have thus again a way paved to more complicated leaf-like structures like that of *Wormskioldia sanguinea.* The exquisite colour, and the variety of forms, often of extreme elegance, simulating the most delicate leaves, or mosses, with infinite interchange of ornament in the form of teeth, fringing hairs, net-work, &c., are attractive to the commonest observer, and have ever made their collection an object of interest to those whom search of health or amusement carries to the coast. In a systematic point of view they recommend themselves to notice by pretty certain indications of sexual distinctions, at least in numerous genera, and by the double form under which the reproductive bodies appear in almost every genus. The one consists of tetraspores arising from the division of a single endochrome in certain privileged cells, and variously situated, always in distinct individuals ; the other, in a collection of organisable tissue, more or less distinct from the general mass, sometimes free, sometimes immersed; consisting of a number of articulated threads in distinct hollow conceptacles, or wart-like tubercles variously situated, the joints of which are to a greater or less extent transformed into spores, sometimes every joint, sometimes one or two only, whether terminal or central, with a mixture sometimes of barren threads; of similar threads immersed in the substance of the frond, without any distinct conceptacle; or finally entirely free, though still collected in fascicles, and occasionally surrounded with an involucre of short branchlets. In every case the perfect spore consists of a dense grumous mass surrounded by a hyaline subgelatinous coat, consisting of at least two membranes. The germination of these bodies has been well described by Agardh. The situation, mode of growth, structure, &c., of the conceptacles varies almost infinitely, and these modifications, combined with the structure of the frond, afford the distinctive marks by which the genera are separated from each other. Besides the conversion of the upper joints of moniliform threads into so many spores, there is another mode of fructification which requires notice. This cannot be given better than in the words of Dr. Harvey: "In the less organised families (*Gongylospermeæ*), the nucleus is formed either from a single mother cell, from several detached mother cells, or from such cells imperfectly joined together in moniliform strings issuing from a central point or growing from the placenta of a conceptacle. Each mother cell, which is at first filled with a homogeneous endochrome, becomes by repeated cell division converted into a cluster of spores at first retained within its walls; afterwards on the bursting of the wall dispersed. Thus by the evolution of one cell, a favella, or simple globose nucleus, containing many spores within a hyaline periderm, is formed; by the evolution of several detached but adjacent mother-cells, a compound favella or favellidium results, and by the similar evolution of the cells of the moniliform series the highest form of favellidium is produced. In all these cases the general nucleus, as well as the particular nucleoli, is surrounded by a gelatinous or submembranaceous hyaline periderm."

145. The tetraspores, like the conceptacles, vary greatly in situation; sometimes they are lodged in particular wart-like excrescences, sometimes in minute leaflets, or in linear organs in which they are arranged in parallel rows, sometimes in the substance of the frond, at a greater or less depth beneath the surface. They mostly consist of a globe

* See, however, *Nothogenia variolosa*, Mont.

broken up into four pyramidal masses from the centre, or in those cases in which an elongated or elliptic form is assumed, by three parallel divisions, or by one or more parallel divisions, with the addition of one in a vertical direction. The former were once considered as ternate granules, but it is evident that in a globe so divided, if the point of juncture of three divisions occupies the centre of the point of view, the fourth will be wholly concealed.*

146. A discussion was moved some years since, in a very ingenious and beautifully illustrated memoir on the Algæ of the Red Sea, as to the relative value of these two forms of fruit, by Decaisne. He inclined to the view that the more perfect form was exhibited by the tetraspores, but as this mode of growth is normal in many of the lower Algæ, and is in them certainly inferior to the formation of spores in the conjugate Algæ, or even to the cysts of *Vaucheria*, I cannot subscribe to his notion, but regard the tetrasporic form as requiring a very inferior effort of nature. Indeed, it is probable that the notion is correct which regards them rather as a sort of buds, a notion which is supported by the fact, that the plants which bear them are generally more luxuriant than those which produce the other form of fruit. What it is which leads one plant constantly to produce a particular form of fruit, is at present a matter of which we can only profess our complete ignorance; though the fact of two kinds of fruit being produced, not only in such genera as *Atriplex*, but in a multitude of *Compositæ*, which yet give rise to plants which cannot be distinguished from each other, is so much in point, that we ought not to be surprised at something similar taking place in Algæ. As the point is one at a satisfactory solution of which we are not at present likely to arrive, we may content ourselves with our knowledge of the fact, considering it meanwhile as one of those wonders which abound so greatly amongst Cryptogams. Both these forms are equally capable of propagating their species, but it is very probable that for this end the concep-

* In the curious *Lepidostrobus*, figured by Mr. Brown in the Linnæan Transactions, one of the four divisions of the spores is usually suppressed.

tacular requires the presence of spermatozoids, which are so abundantly produced in many genera. The British Algæ of Dr. Harvey, the plates of the Supplement to English Botany, the treatises of Derbès and Solier, together with that of Thuret, so often quoted, exhibit numerous cases.* It is very true that their necessity has not been proved by experiment, but the bodies in question are in essential structure and outward appearance, except perhaps the filiform appendages, similar to those so common in Chlorosperms, which we know to be often reproductive, besides which there are very numerous genera in which their presence has not been verified. But even granting the supposition that in many genera they do not exist, this is no argument against the cases in which they do; and as their fecundative powers have been ascertained in Melanosperms, we have no reason to doubt that they are similar in Rhodosperms, where they are never known to germinate.

147. Though the divisional and generic characters depend, in great measure, on the nature and disposition of the fruit, it will be impossible to separate these Algæ into natural groups, without paying attention to the structure of the frond. This was first adopted by the younger Agardh, who, in consequence, made many improvements in the disposition of species; but, like the venation of ferns, the characters so derived are sometimes pushed to such an extent as to separate plants which really ought to be united. Unfortunately the structure of these plants is not always easily understood, especially without some practice, in consequence of the quantity of mucilage which enters into their composition, and of the transition from cells to filaments. Much information on this head may be derived from Kützing's admirable plates, and the works of Dr. Harvey may be consulted with great advantage.

148. The structure of both Rhodosperms and Melanosperms is often very difficult to make out, on account of the divisions between the separate cells being extremely obscure.

* Mrs. Griffiths, to whom we are indebted for so many discoveries, had long observed these matters before their importance was recognised by systematists, and I am indebted to her kindness for many illustrative specimens.

Slightly, and I may add truly, as these are often indicated in Kützing's exquisite plates, they are often still more obscurely marked under the microscope. The endochromes of neighbouring cells often communicate by more or less delicate threads,* by which, probably, the same purpose is answered as by the canals so frequent in the cells of Phænogams. Sometimes the processes of the endochromes seem to terminate in real canals, answering to those of a neighbouring cell. There are, besides, frequently large intercellular spaces, and the walls of the cells, when well developed, often show distinct strata. The cells, moreover, pass abruptly from sacs into threads, or the contrary, exhibiting great variety of form in the same part of a plant, and in the same plane or section, and it often happens that towards the circumference the walls are so intimately combined, that a thin slice merely shows a firm transparent mass, perforated with cavities, and this even in cases where the component threads or cells are mostly free, as, for instance, in *Furcellaria fastigiata*. The cells themselves, as also the spores, often contain distinct free granules, which (Fig. 46, *d*), in the former case, at least, appear to be amylaceous.

149. Rhodosperms, though their genera have often definite geographical limits, do not differ greatly as a whole, in this respect, from the other divisions of Algæ. They are found in every sea, and while *Iridæa radula*, Bory, accompanies *Adenocystis Lessonia*, and a magnificent *Scytothalia*, in Cockburn Island, beyond the 60° of south latitude, the Chlorosperms being represented on the shore by *Ulva crispa* and an *Oscillatoria*, there are representatives of the three great divisions in the northern hemisphere, at least as high as 73°. *Laminaria Saccharina* has been found as high as 74.40, and an *Oscillatoria* in 75.49, and, probably, even there, Rhodosperms have not entirely ceased. Though, however, they form vast masses in many latitudes, these cannot be compared with

* An example of communicating endochromes is figured at Fig. 44, *d*, from the tissue which surrounds the conceptacles of *Gigartina pistillata*, the divisions of the several cells being invisible under the microscope.

those of the Melanosperms, one or two genera of which, probably, outweigh, in this respect, all other Algæ put together.

150. The two following divisions comprise the several forms:

1. *Gongylospermeæ.* Nucleus simple or compound. Endochromes divided, spores at length conglobated.

2. *Desmiospermeæ.* Nucleus consisting of tufted spore-threads, adhering to a placenta. Endochromes single.

These groups are again divisible, as in the following tabular view :

RHODOSPERMEÆ.	*Gongylospermeæ*.—(Spores indefinite, produced within mother cells.)	Filiform articulate.	*Ceramiaceæ.*		Nucleus naked.
			Spyridiaceæ.		Nucleus inclosed in a pericarp; compound.
		Compound inarticulate.	*Cryptonemiaceæ.*		Spores at length conglobated, generated in solitary or aggregate cells.
			Rhodymeniaceæ.		Spores at length conglobated, generated within the cells of moniliform threads.
	Desmiospermeæ.—(Spores single in the upper joints of the threads of the nucleus.)	Nucleus not conceptacular.	Nuclei naked.		*Wrangeliaceæ.*
			Nuclei immersed.		*Helminthocladiæ.*
			Nuclei in raised warts.		*Squamariæ.* — Lichenoid, horizontal.
					Spongiocarpeæ. — Cylindrical.
		Nucleus conceptacular.	Placenta parietal.		*Chætangieæ.*
			Placenta axile or suspended.		*Gelidiaceæ.*
			Placenta basal.	Spores in strings.	*Sphærococcoideæ.*— Cartilaginous or membranous.
					Corallinaceæ.—Calcareous.
				Spores terminal.	*Laurenciaceæ.*— Inarticulate.
					Rhodomeliaceæ. — Articulate or with an articulate axis.

I. Gongylospermeæ, *J. Ag.*

Nucleus naked, or immersed in the frond, sometimes contained in a distinct external conceptacle, simple or consisting of several secondary nuclei (nucleoli); spores conglobated without any definite order.

151. The first great division of the *Florideæ* is characterised by the numerous spores collected within a hyaline sac, and not radiating, except occasionally at their first origin, from a common centre, but distributed without order. The nuclei are either solitary (Fig. 43) or compound (Fig. 44, *c*), and in some instances are quite naked, without any trace of a conceptacle.* In some cases it requires some attention to ascertain the real structure of the fructifying mass, inasmuch as where the placenta is reduced to a mere point, and the spores radiate from a common centre, it is very easy to imagine that the sac is simply filled with spores disposed without any definite order. The divisions are less numerous than in the other main division, but some of the genera, as *Gigartina, Ceramium*, and *Callithamnion*, abound in species, even after reducing numerous varieties to their normal types. There are few of the more frondose species, perhaps, which can vie with *Delesseria* or *Amansia*, in delicacy of frond or essential elegance, but there are still many fine species, especially amongst the analogous forms; and amongst the articulate and filiform kinds there are productions which may bear 'comparison, for beauty, with the whole vegetable world. The divisions depend partly on the structure of the fronds, and partly on the mode of origination of the spores; and there are many analogies, in respect of the frond, where the fruit is altogether different. Like other analogies, they are often deceptive, and

* In generic characters, the perfect condition of the conceptacles is always meant, except something is expressed to the contrary. Where the spores are conglobated, there is either a successive development of joints from above downwards, or new spores are produced in new cells generated where the old ones have fallen off. Cavities which are at first merely lined with an hymenium, having a single stratum of spores, are thus, at length, filled up in some of the Hypogœous and allied *Fungi*, with a compact mass of fruit.

if the first conclusions to which they lead were adopted, the whole system would be soon reduced to the primitive chaos which existed at the time when Turner began his history of Fuci. Most of the genera have representatives in every part of the globe, but the filiform species are more abundant in temperate seas, while a few attain, in warmer countries, their extreme dimensions.

1. CERAMIACEÆ, *Harv.* (*Ceramieæ*, J. Ag.)

Articulate, often more or less coated with cells. Nuclei naked or involucrate. Spores conglobated. Tetraspores superficial.

152. This group contains a portion of those Rhodosperms which are either strictly monosiphonous and filiform, or which

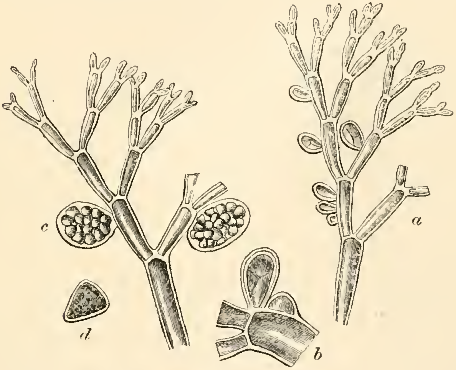

Fig. 43.

Callithamnion corymbosum.

a. Thread with tetraspores, magnified.

b. Portion of ditto, magnified more highly.

c. Thread with naked nuclei, filled with a mass of spores, magnified. (GONGYLOSPERMEI.)

d. Spore magnified more highly.

From specimens communicated by Mrs. Griffiths.*

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* I have also a specimen from the same lady, showing the antheridia as in Harvey's figure; but they are so delicate that I am not able to figure them from the dried specimen.

12

are more simple in their structure than others, approaching, in this respect, *Confervæ*. It abounds in species which display the most exquisite combination of ramification and colouring. The nuclei, which arise from transformed joints, are entirely naked, or involucrate, simple, and filled with a mass of spores, arranged according to no definite plan. *Antheridia* have been observed in many species filled with active spermatozoids. The threads are either strictly simple, or coated with filaments or cells, frequently in transverse lines. The tetraspores are often seated on the thickened parts in those species whose frond makes an approach to inarticulate forms, but are sometimes contained in particular processes. In *Ptilota* and *Microcladia* there is no external appearance of articulation, as in *Ceramium*. They are completely coated with cells, though there is still an articulated axis.

153. A large portion of our *Nereis* is composed of individuals of this tribe, as they abound on our coasts in every little rocky pool, on every piece of woodwork exposed to the waves, on rocks and stones, and, above all, on the stems of the larger or firmer Algæ, or even on marine Phænogams, which they fringe in the most exquisite way with every shade of red, from a bright rose to purple. They are represented by numerous species in the southern hemisphere, and one or two *Ptilotæ* are amongst the most beautiful ornaments of subtropical seas, nor, indeed, are our own seas destitute of the more highly organised forms. There are, however, several genera which do not affect more temperate regions. *Microcladia glandulosa* is a rare inhabitant of our southern coasts, and differs from *Ceramium* in its compressed fronds, besides other characters. No genus is more natural than *Ceramium* itself. It comprises many well-characterised species, several of which occur on our coasts, and some of them are remarkable for their spinulose branchlets. They are extremely elegant, from their transverse alternate bands of white and red, and in almost all the dichotomous branching and forcipate tips are very striking. Besides these, however, there is a multitude of spurious species which must eventually be weeded out of the system. The species of North America are, for the most part, those of our

coasts. *Crouania* is remarkable for possessing the habit of *Batrachospermum.* *Halurus* and *Griffithsia* have their representatives all round our coasts, but are also found in the southern hemisphere, where also a large number of species of *Callithamnion* occur, though they are more numerous northwards.

2. Spyridiaceæ, *Harv.* (*Spyridieæ*, J. Ag.)

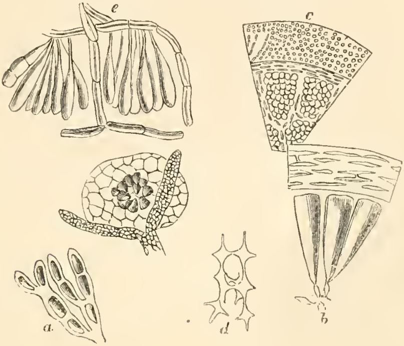

Fig. 44.

a. Conceptacle of *Spyridia filamentosa,* Harvey, magnified. From a specimen communicated by Mrs. Griffiths,* with the threads in which the spores are generated from the endochromes.

b. Transverse section of conceptacle of *Chylocladia Kaliformis,* Grev. showing the origin of the spores from the central placenta, magnified. From a specimen communicated by M. Lenormand.†

c. Vertical section of the conceptacle of *Gigartina Teedii,* magnified. From Sir W. J. Hooker's Herbarium.

d. Endochromes in the tissue surrounding the conceptacles of *Gigartina pistillata,* to show their communication with each other, highly magnified. From a specimen received from Lenormand.

e. Portion of conceptacle of *Solieria chordalis,* after Harvey.

* The conceptacles are usually lobed, and there are several distinct masses of spores. The simplest case is purposely represented, to show the advance which has been made from the naked nuclei of *Callithamnion.*

† The walls of the conceptacle appear very different in different sections, according as the section happens to divide the component cells.

Frond monosiphonous, coated more or less with cells. Conceptacles external, consisting of a nucleus inclosed in a mouthless perithecium. Nucleoli several, formed of branched threads, whose upper cells produce spores by division of their endochrome ; spores at length conglobated.

154. The few remaining Rhodosperms with filiform and monosiphonous threads, contained in this division, are distinguished at once by their fructification. In the present case the compound nuclei are lodged in an external conceptacle. They are formed from fascicles of threads springing from a common point, whose upper cells produce a multitude of spores by the repeated division of their endochrome. The frond is composed of a central thread coated with more slender filaments, or in some parts with cells, and is repeatedly branched, cylindrical, or slightly compressed, and clothed with deciduous articulated branchlets. The division consists of a single genus, whose species affect, for the most part, tropical or sub-tropical seas, extending as far south as Tasmania. Two or three are found in the Indian Ocean, and one of these occurs on the coast of Brazil. One species only occurs in the south of England, and extends as far as Algiers, and on the eastern coast of North America it has an analogous range. Dr. Harvey conjectures that *Ballia*, a beautiful sub-tropical genus exactly analogous to *Sphacelaria*, may be closely allied. At present, however, its fruit is imperfectly known.

3. CRYPTONEMIACEÆ, *Harv.* (*Cryptonemeæ*, &c., J. Ag.)

Frond inarticulate, varying in texture, composed of articulated threads closely incorporated, or, in the membranous species, of cells. Nucleus sunk or contained in an external conceptacle, simple or compound. Spores conglobated.

155. The distinctive difference between this and the following division, consists in the spores being disposed without order in the nuclei. It comprises species differing greatly in structure as regards the frond, for while some are composed entirely of filaments compacted together, others are as decidedly cellular. The genera are numerous, and are separated by Agardh into two sections, *Gigartineæ* and *Cryptonemeæ*, one of them characterised by a compound (Fig. 44, *c*), the other by a simple

nucleus (Fig. 44, *b*), both of which are united by Harvey for the very sufficient reason that the difference is one only of degree, while there is the most intimate relation in structure and habit.

156. The numerous genera, of which thirty-five are proposed by Agardh in his most recent general work on Algæ, are dispersed through all regions, though, perhaps, more common in the northern hemisphere. Many are inhabitants of the warmer seas, and we have several representatives in Britain. Twenty-four genera, at least, occur on the east coast of North America. *Stenogramma*, which has been found on our extreme southern coasts, occurs in California and Florida, in addition to Spain, as far as Cadiz, and is very fine and abundant in New Zealand. It is remarkable for the disposition of the nuclei on each side of the central nerve, exactly after the fashion of some ferns. *Phyllophora, Gymnogongrus, Ahnfeltia, Cystoclonium, Callophyllis, Kallymenia, Gigartina, Iridæa, Chondrus, Halymenia, Furcellaria, Chrysymenia, Grateloupia, Catenella, Glœosiphonia*, have all representatives on our coasts. The various species of *Chondrus* supply the greater part of the Carrageen of commerce. One of the most beautiful of seaweeds is *Constantinea rosa marina*, two of the species of which genus occur in Kamschatcha, or other high latitudes, while the third is found in the Mediterranean. The stem is sometimes a foot and a half high, fixed to stones or shells, and branched from the base; the branches are flexuous, round, and naked, 1-2 lines thick; horny when dry, annulated; rings 2-3 lines distant. Towards the top of the stem and branches are a number of whorled laminæ, the terminal ones being peltate; the whole bearing some resemblance to an expanded rose. As the lower laminæ grow old, they fall off and leave rings upon the stem. The ultimate fronds rarely remain orbicular and entire. The central one is about two inches in diameter, and divided into from 3-6 obovate spathulate lobes.* *Constantinea Sitchensis* is a larger species, the solitary terminal orbicular lamina attaining a diameter of from four to six inches. *Chy-*

* J. Agardh, Sp. Alg., vol. 2, p. 295.

locladia articulata also, which is one of the most frequent species on our coasts, deserves notice, from the elegant chains of elliptic articulations of which the frond is composed, which never fail to excite the admiration of those who meet with well-grown specimens, and it has the advantage of preserving the greater part of its beauty when dry. *Glœosiphonia* is remarkable for its gelatinous frond. It is one of the most beautiful Algæ of our coasts, and rather rare, though widely diffused.

4. Rhodymeniaceæ, *Harv.* (*Rhodymenieæ*, J. Ag.)

Inarticulate, membranaceous, cellular; nucleus in an external conceptacle, simple or compound. Spores at first in moniliform threads, at length conglobated.

157. The frond, in the Algæ of this division, is inarticulate and mostly flat, though varying considerably in form, being sometimes cylindrical. The colour is in some of a dull reddish purple, while in others it is of a fine blood-red. The nucleus is lodged in globose conceptacles, and the spores are produced within the joints of moniliform threads, and at length are dispersed within the sac, without any definite arrangement. Occasionally the moniliform threads of the nucleus are disposed in separate chambers by means of threads proceeding to the walls, as we shall see again, in the *Gelidiaceæ.* The endochromes of certain privileged joints of these threads suffer repeated division, and on the absorption of the walls of the parent cell are dispersed without order in the common cavity, or in the partial chambers. It is obvious that at an early stage of growth they could not be distinguished from Algæ, with ordinary moniliform threads. The spores themselves, according to their number, will either retain their original form, or become angular, from mutual pressure. An accurate study of the fruit is so much the more necessary, because the frond, as regards structure, is often so exactly like that of analogous forms as to defy the most practised eye. This is truly a great inconvenience to the student; but if a really natural system is to be adopted, depending not upon external resemblance merely, but upon intimate structure, such difficulties will constantly arise. Amongst the patellæform mol-

lusca for instance, so long as mere external characters alone were regarded, genera of the most widely different structure were constantly confounded, and mere analogies are every day deceiving those who are content merely with the surfaces of things. Still, in some cases, I am inclined to think that the mere division of the endochromes is not sufficient to authorise a distant separation. *Rhabdonia* (Fig. 45, *a*) and *Solieria* (Fig. 44, *e*) are so circumstanced. The mere division of the endochrome is certainly in many cases not of generic importance in Fungi, and perhaps its importance has been exaggerated in some cases where Algæ of similar habit are concerned.

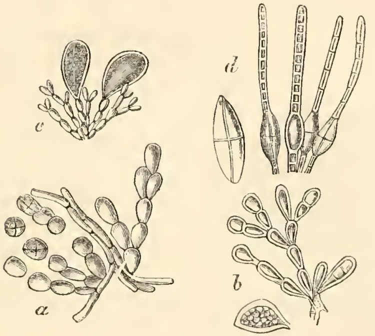

Fig. 45.

a. Portion of nucleus of *Rhabdonia Coulteri*, Harv., magnified, showing the separate cells, with the dissepiments and spores, after Harvey.

b. Portion of nucleus of *Sphærococcus coronopifolius*, Ag., and single spore, magnified. (Desmiospermeæ.)

c. Spore-threads of *Wrangelia penicillata*, Ag., after Harvey.

d. Tetraspores of *Cruoria pellita*, Fr., from a specimen gathered by Mr. Ralfs, April, 1842. (*Petrocelis cruenta*, J. Ag.)

158. Both the genera and species of this division have frequently a wide range. The commonest of all red seaweeds on our coast, and one of the most elegant, *Plocamium coccineum*, is found all over the world; while all the other species of the genus, which, perhaps, have been too much multiplied, are

natives of the southern hemisphere. *Wormskioldia sanguinea,* which extends north as far as the Feroe Islands, occurs again at Cape Horn. *Rhodymenia palmata* is one of the best of the esculent seaweeds, but perhaps the most agreeable form in which it can be eaten is simply as it comes from the sea, when it forms a palatable article of food enough, where other food is not be procured. All the efforts, however, of M. Soyer cannot conceal in it, when cooked, a peculiar flavour of Iodine, which is inseparable from Carrageen in any shape in which at present it has come before me. A purple dye has been prepared from it. *Rhodymenia, Euthora, Rhodophyllis,* and *Cordylecladia,* all afford species to our Nereis; *Rhabdonia* alone, of the North American genera, is unrepresented, and that is confined at present to the north west shores. *Wormskioldia sanguinea* is so extremely like some of the *Delesseriæ,* especially those which occur in the southern hemisphere, that at first sight it seems the most unnatural thing in the world to separate them. But, similar as the fronds are, the fructification is so completely dissimilar, that we must give up the structure of the nucleus altogether, as affording distinctive characters, if they are to be associated. In the former there are elliptic spores by no means forming moniliform threads, but separated into little rows by a peculiar tissue; while in the other there are beautiful moniliform threads, with the spores sometimes forming their terminal joints, sometimes radiating at their base. It is, in fact, a most striking instance of analogy without affinity.

II. DESMIOSPERMEÆ, *J. Ag.*

Frond articulate or inarticulate, cartilaginous, membranaceous or filiform; nucleus consisting of tufted spore-threads, arising from a placenta. Spores formed singly in each cell of the sporethread, or only in the terminal cell.

159. The first great division of Rhodosperms was distinguished by the spores being ultimately disposed without order in the nuclei, whether simple or compound. In the more typical species this was evident enough, but in the early stage of one or two genera, though the spores ultimately fell off, the endochromes dividing into several distinct spores, before the

spores had fallen, and before cell-division had taken place, it was not possible to distinguish them from true forms of the present division. How far the division may in the end prove tenable it is scarcely possible to surmise at present. There will always be exceptions in any arrangement which may be devised, be our knowledge extensive as it may.

160. The number of distinct divisions and genera, and the variety of forms, are very large, and we have here again species remarkable for the quantity of calcareous matter which they appropriate, even more so than those which were described amongst Chlorosperms, many of which occur on our own coasts as well as in warmer seas. The filiform species are numerous, and some of them extremely beautiful, while many of the membranous species are remarkable for the delicacy of their fronds, or the symmetry of their composition. The regular net-work of some of these Algæ is as exquisite as that which we have seen lately amongst *Hydrodictyæ;* and amongst the membranous and sub-cartilaginous groups there is cancellated work of the most surprising beauty. Some of these more curious forms are confined within narrow geographical limits. A few of the filiform species are habitants of brackish waters, and in the tropics ascend rapid torrents on the coasts.

5. WRANGELIACEÆ, *Harv.* (*Wrangelieæ*, J. Ag.)

Threads filiform, articulated, sometimes partially coated with cells. Nucleus surrounded by a whorl of byssoid branchlets, and composed of radiating pyriform spores, arising from the endochromes of the terminal cells. (Fig. 45, *c.*)

161. These differ from other *Desmiospermeæ* in the exposed involucrate nuclei. The habit is that of *Callithamnion*, and, like many species of that genus, they consist of a central thread, coated more or less with smaller ones, sometimes disposed so as to form the most elegant lacework; in some, however, there are no external cells or filaments, as in *W. multifida.* There is but one genus, unless *Naccaria* be included, consisting of several species, the greater part of which belong to the southern seas, while the original one is a well-known native of our coasts. As regards the tetraspores, the resemblance between this genus and *Callithamnion* is complete, but there is no resemblance between the

favellæ of that genus, with their indefinite spores, and the moniliform spore-threads of this. (Fig. 45, *c*.) The genus is not confined to the southern seas, or Europe, but occurs also both at Key West, in North America, and at Vera Cruz, where it was found by Liebmann. *Naccaria* also occurs on our coasts, and differs remarkably from *Wrangelia* in its inarticulate frond. This, however, is merely a question of degree. In the structure of the fruit both agree perfectly, as far as the spore-threads and spores are concerned; but in one they invest the short swollen fructifying branchlets, in the other they are formed at the truncated tips. In *Wrangelia*, that is, they are more condensed than in *Naccaria*.

6. HELMINTHOCLADIÆ, *J. Ag.*

Frond more or less gelatinous, essentially filamentous, though closely compacted. Nucleus immersed without any conceptacle, formed of radiating sporiferous threads.

162. In each of the three great divisions of Algæ, there is a group separated from the rest, by peculiar habit and similarity of structure. A central thread or axis gives off, in its course, a number of short, horizontal, close-packed branches; the whole constituting a flaccid, gelatinous, flexible frond, which varies in colour with the division to which it belongs. But, besides these three groups, there are genera with similar habits, as *Dudresnaia*, *Crouania*, and *Glœosiphonia*, which form representatives in *Ceramiaceæ* and *Cryptonemiaceæ*. In the present instance the cylindrical frond is red. The nucleus has no surrounding walls, but is immersed amongst the constituent filaments and is composed of branched spore-threads breaking up into spores. In the genus *Scinaia*, however, both Dr. Montagne and Harvey have seen, with greater or less distinctness, a delicate membranous envelope. Tetraspores at present have been discovered in *Nemalion* only.

163. As regards geographical distribution, *Liagora* and *Scinaia* are lovers of warm seas, and the former is common everywhere in such situations, one species being found by Messrs. Crouan at Brest, while the latter ascends as high as the southern coasts of England, under the form of the old *Ulva furcellata*. The other genera are either European or American,

or both. *Nemalion virens* occurs on the Pacific coast of Mexico; *Nemalion multifidum* is not uncommon on our rocky coasts, occupying frequently the shells of *Balani.* Besides the central threads and horizontal filaments, others are given off from the latter after the fashion of roots, a circumstance which occurs in other Algæ, as for instance in *Leathesia Berkeleii,* and some *Chætophoræ.* Agardh compares the development of the frond to that of an endogenous stem. It consists of a medullary stratum formed of longitudinal simple filaments, an intermediate layer of obliquely horizontal anastomosing filaments, and a periphery of horizontal dichotomous fastigiate filaments. The descending threads are doubtless analogous to those of *Callithamnion;* and if the branches were increased infinitely in number, and still sent down their descending filaments, we should have very much the same structure. *Helminthora divaricata* is also an inhabitant of similar coasts, extending with the last to the northern parts of our island. Both were found at Appin, by Captain Carmichael, and pointed out to me there by him in 1824. *Liagora* differs from the rest in appropriating a large quantity of calcareous matter in which it resembles the strictly analogous flat-fronded or cylindrical *Chætophoræ,* though other species of that genus abound in crystals of carbonate of lime. *Liagora,* when dry, often asssumes a green tinge, which makes the resemblance the closer; but when fresh it has the colouring proper to the Rhodosperms.

7. SQUAMARIÆ, *J. Ag.*

Frond lichenoid, crust-like, rooting beneath. Spores in moniliform strings, lodged in wart-like excrescences.

164. Besides those florid, chain-spored Algæ, which have conceptacles, either entirely distinct from the frond, slightly immersed at the base, or absolutely naked, there are others whose fructifying nucleus is not lodged in a hollow conceptacle, but in wart-like excrescences in the frond itself. This is a small division, and consists of Algæ, with licheniform fronds, producing warts on their upper surface, which contain tufts of moniliform threads. The only certain tenants of this division are *Peyssonnelia,* which was proposed originally by Decaisne,

and *Cruoria*, J. Ag. *Peyssonnelia* grows on shells and other marine bodies, and extends from the Mediterranean to Ireland, and the opposite Atlantic shore of North America. The analogy between this genus and *Ralfsia*, is very striking. A number of other plants of similar habits, adhering under the form of an almost inseparable crust, with one or two which grow upon such Algæ as *Phyllophora rubens*, but of doubtful affinities, in consequence of our comparative ignorance of their fructification, have been placed here by Agardh, jun. Several of these, as *Petrocelis cruenta*, *Hildenbrantia Crouani*, *H. rivularis*, *Contarinia Peyssonneliæformis*, and probably several others, occur on our coasts; for almost all belong to the temperate seas of the northern hemisphere. One alone has at present occurred in Australia. *Peyssonneliæ* also occur at Port Natal, under two forms. As far as these plants are known there is very little to separate them from the squamæform corallines, except the absence of calcareous matter. The fruit, though contained in conceptacles, as in *Hildenbrantia*, is really in the form of tetraspores, as in corallines. If this be not conceptacular, that form of fruit is at present wholly unknown. *Petrocelis cruenta** is a curious microscopic object. Dr. Harvey found certain swellings in the threads, confined to a single joint, the nature of which he could not determine, but in a specimen in my herbarium, from Mr. Ralfs, I find these converted into tetraspores (Fig. 45, *d*) as distinctly as in any other Rhodosperm. The same specimen, moreover, shows beneath distinct lines of growth. I find the length of the joints extremely variable. In Scotch specimens the filaments are disposed in little fascicles, and there is something of the same structure, but not so evident, in other specimens. In

* This is *Cruoria pellita* of Fries and Harvey. I believe the plants of Areschoug, Lyngbye, Flora Danica, and Harvey to be identical. I have in vain sought for fruit in the plant of Desmazières, which is that in which Agardh has seen fruit different from that here figured, and on which he has founded his genus *Cruoria*. As regards the mere threads, it does not differ from specimens from Carmichael and Ralfs. In all, they are slightly branched above. J. Agardh has no evidence to show that his *Cruoria pellita* belongs to a different genus from his *Petrocelis cruenta*.

the figure in *Flora Danica*, the tetraspores are represented several together in the same thread. I have in vain hunted for fruit on an Appin specimen, from Captain Carmichael. The tetraspores figured by him had probably fallen down amongst the component threads.

8. SPONGIOCARPEÆ, *Grev.*

Cylindrical, cartilaginous, composed of a central column of interlaced threads and radiating cells. Nuclei contained in lateral elongated spongy warts. Spores large, obconical, radiating from the centre of each nucleus.

165. This section consists of a single genus, whose fruit is so abnormal that Captain Carmichael regarded it as parasitic. The nuclei are scattered through the substance of irregular spongy warts, which are composed of articulate threads, precisely like those of the tissue from which they spring, and are perfectly hyaline, with a cluster of obconic spores radiating in every direction from their centre.* There is obviously a great similarity between the tissues of the main frond of *Polyides* and *Furcellaria;* but the structure of the fruit is so utterly at variance, that it is impossible to consider the one a mere modification of the other. In *Furcellaria,* the fruit consists of favellæ (Fig. 46, *c*) irregularly seated, or placed one above another so close that they at length become confluent, each of which is formed of conglomerate irregular spores, destitute of any definite arrangement. The tetraspores (f. c. *e*) are divided by three annular sections, while in *Polyides* (f. c. *b*) they are formed by two sections, one of which is vertical, the other horizontal. Perhaps no better instance could be brought forward of the absolute necessity of close study, to arrive at a correct knowledge of the nature and relations even of objects which are daily under our eyes. The species extends north, as far as Iceland, and south to the Adriatic Sea, or the southern part of France, and perhaps Spain. It is rare off the North American coast, but has been found at New York and Boston. It is essentially a plant of cold or temperate climates.

166. The younger Agardh, however, in his species, Genera

* See Caspary Annals, Nat. Hist. n. s., v. 6, p. 87.

et Ordines, Algarum, 1851, places *Spongiocarpeæ* in his order *Chondrieæ*, associating it with *Lomentaria* and *Laurencia*, though in a different tribe. But the spongy fruit of the one

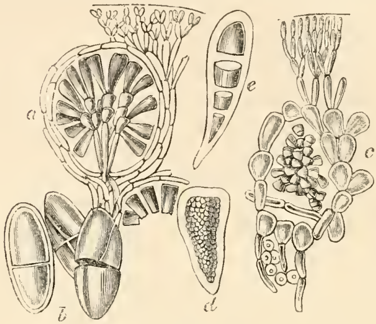

Fig. 46.

a. Thin slice of *Polyides rotundus*, Grev., showing the wedge-shaped spores radiating in every direction, magnified. One nucleus is divided through the centre; a portion only of a second is seen beneath.

b. Tetraspores young and old, magnified. Both from Mrs. Griffiths.

c. Thin slice of *Furcellaria fastigiata*, Lyngb., magnified, showing a nucleus with the dividing spores. From a specimen communicated by Lenormand.*

d. One of the large cells, to show its granular contents, which are of a beautiful violet, when treated with the compound iodide of potassium and sulphuric acid. The contents of the spores, on the contrary, become yellowish brown.

e. Tetraspore, after Harvey. All more or less magnified.

filled with nuclei, can scarcely be compared with the naked conceptacles of *Chondria*, with their single nucleus and basal spores. Dr. Harvey's notion, however, of the fruit does not accord with my observations. The placenta arises either distinctly

* Unfortunately, I can find no fruit in specimens from Mrs. Griffiths, supposed to have perfect spores, and cannot, therefore, compare what I find in Lenormand's specimen with the plant as examined by Harvey. The differences, however, are of little importance. One great distinction in the structure of *Polyides* and *Furcellaria* is, that in the latter so many horizontal cells traverse the medullary fibres, as represented in the figure. The external cells vary extremely in length.

from the base, as represented in my figure, or from some other portion of the walls, though the spores radiate from the centre of the nucleus, and the cells in the incrassated portion of the placenta are distinctly though irregularly moniliform. The only resemblance is in the cuneiform spores, which have already been seen in *Chylocladia* (Fig. 44, *b*).

9. CHÆTANGIEÆ, *Kütz.*

Frond cartilaginous; conceptacles immersed in the medullary substance, producing articulated threads from every part of their walls which converge to the centre, the terminal joint of each branchlet producing a spore.

167. The curious Algæ in this division are peculiar to the southern hemisphere. Species occur at the Cape, the Auckland group, the Falkland Isles, Chili, and New Zealand, and, if *Porphyroglossum* is allied, in Java. They are characterised by the confluence of the placenta with the cavity of the conceptacle, every part of which gives rise to articulated threads scattered or in fascicles converging towards the centre, and bearing at the tip of each branchlet a single spore, which has a single envelope. I have already pointed out, in the last division, that the placenta is not always basal; and, supposing the fertile points to be multiplied, we have the structure just mentioned, which is in fact nearly that of the fruit of *Fucaceæ.* Dr. Harvey remarks* that it is possible that they may eventually prove to have a close relationship with *Pterocladia.* I have figured the placentation in *Gelidium* (Fig. 47, *c*), and the portion of the axis which bears the spore threads, or in other words the placenta, instead of passing through the centre of the cavity, is confined to one side only, we shall have the lateral placentation of *Pterocladia.* I am myself rather inclined to compare the conceptacles with those of *Polyides*, where the development of the spore-threads from the axis is confused, whether the cavities in which they are produced be considered nuclei or nucleoli. Dr. Kützing was the first to

* Nereis Bor. Am. part ii., p. 114. I am sorry that the fruit in my own specimens is in a very early stage. The extremely delicate threads of which the medullary substance is composed, giving rise to moniliform threads on the surface, are very peculiar.

propose the division, but we are indebted to Dr. Montagne for almost the only illustrations we possess of the peculiar structure* of the conceptacular fruit. The tetrasporic fruit of *Apophlœa* is figured in the Flora of New Zealand, and may be compared with that of *Ctenodus*.

10. Gelidiaceæ, *J. Ag.*

Inarticulate, cartilaginous; axis composed of confervoid threads; conceptacles semi-immersed. Spores attached to a network of threads, or to a fibro-cellular placenta, which either adheres to one wall of the cavity, or runs through its centre, dividing it into two chambers.

168. This division commences the series of Algæ with hollow, more or less, external conceptacles, and is distinguished from the others by its axial or suspended placenta. The frond is opake and of a firm texture. They are, for the most part, southern, tropical or sub-tropical Algæ; but *Gelidium corneum*, the most variable, perhaps, of all plants, occurs in almost all parts of the world, and is a very common British Algæ. *Hypnea musciformis* is also very widely diffused, but does not come so far north as Great Britain.

169. The hooked swollen tips of *Hypnea* are very curious, and resemble greatly those of the threads in certain Fungi. *Gelidium cartilagineum*, which is a very doubtful inhabitant of our coasts, is remarkable for the various tints which it assumes under varying circumstances. Originally of a dark brownish purple red, on exposure to the air it changes, through various brilliant tints of red, orange, yellow, and greenish, to a horny white. Other species of this division have the same property. In *Hypnea* the conceptacles contain numerous roundish clusters of spores attached to anastomosing threads which traverse their cavity; in *Gelidium* the placenta assumes the form of a dissepiment, attached only by the two edges, but connected with the walls by forked threads.† The central

* Voyage au Pole Sud, tab. 10, fig. 3. *Rhodymenia ornata* and *Hombroniana*, as figured in the same work, have very similar conceptacles.

† See Dr. Harvey's figure of *Nitophyllum Gmelini*, in Phyc. Brit. tab. 235. The placenta, though in this case attached on either side, has no connecting filaments. (Fig. 47, *c*, is not quite correct as to the attachment. It was more evident in the drawing.)

placenta of *Eucheuma* is free, except at the very base, and is suspended in the middle of the nucleus by delicate filaments proceeding from it to the walls of the nucleus, while in *Solieria* (Fig. 44, *e*) it is perfectly free, with the exception of similar connecting threads. It is a curious matter that there should

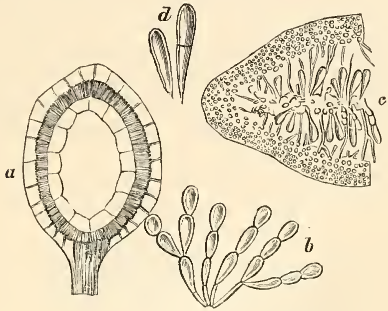

Fig. 47.

a. Nucleus of *Eucheuma isiforme*, J. Ag., showing the placenta attached to the wall of the nucleus by delicate threads, and supported at the base, magnified.

b. Moniliform threads, bearing spores at their apex. Both after Harvey.

c. Transverse section of part of a conceptacle of *Gelidium corneum*, magnified, showing the dissepiment, with the spores growing from its two faces, and the connecting filaments, from a specimen communicated by Mrs. Griffiths.

d. Spores more highly magnified.

be another genus, *Rhabdonia* (Fig. 45, *a*), which differs only in each cell of the moniliform threads, producing numerous spores by the division of its endochrome, and, consequently, comes under a distinct section, at least in an artificial arrangement; for it is quite clear that the multiplication of the spores arises merely from a vital energy carried a step farther than in *Solieria.* Reduce the threads to a single joint, and there is no essential difference.

11. SPHÆROCOCCOIDEÆ, *J. Ag.*

Membranaceous or cartilaginous. Conceptacles distinct, often perforated. Spores (Fig. 45, *b*) formed successively, beginning at the tips, in the joints of moniliform threads which spring from a basal placenta.

170. This section comprises those red Algæ which have their spores lodged in an external subglobose conceptacle, and at the same time whose spore-threads are moniliform, the joints of which, commencing above, separate into many spores. Their frond is either cartilaginous or membranaceous, and totally different in habit from those which follow. It comprises some of our most common and beautiful Algæ, remarkable for their

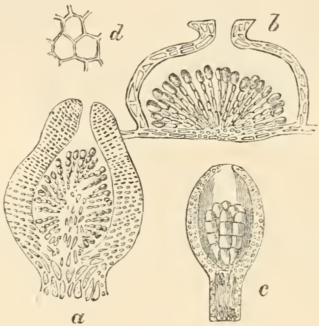

Fig. 48.

a. Vertical section of conceptacle of *Gracilaria armata*, J. Ag., showing the placenta penetrating the cavity of the nucleus, from a specimen received from Lenormand, magnified.

b. Ditto of *Grinnelia Americana*, Harv., showing the rudimentary placenta and spore-threads. After Harvey, magnified.

c. Ditto of *Corallina officinalis*, magnified.

d. Membrane of Ditto, more highly magnified, with impressions of the external cells.

brilliant rose and purple tints. They often assume a frondose aspect from the regularity of the nerves, which sometimes perform the functions of a stem, when the membranous border has decayed, and give rise in turn to new fronds. As regards internal structure nothing can be more various, but they never assume a truly articular form. The tetraspores in some cases are scattered over the whole frond, in others collected in sori, or more rarely contained in special receptacles.

171. The genera and species are for the most part very widely distributed, but abound perhaps more in the northern hemisphere. *Nitophyllum* is, however, very rare on the North American coast; while at the Cape it appears in its most magnificent array, under *N. venosum. Delesseria Leprieurii*, Mont., an inhabitant of tidal rivers, and having the livid hue of *Bostrychia*, ranges from the mouth of the Hudson River to Cayenne, and occurs again at New Zealand. *Sphærococcus* is confined to Europe, while numerous genera are exclusively tenants of the southern hemisphere. *Gracilaria lichenoides*, the Ceylon moss, is celebrated for its gelatinous qualities, as are several allied species of the southern seas. Our own *Gracilaria compressa* is excellent as a pickle or preserve, and very ornamental. One of the most beautiful known Algæ is *Grinnelia Americana*, which abounds on the eastern coast of North America, from Cape Cod to New Jersey, and differs singularly from *Wormskioldia sanguinea*, of which it is an exact analogue, in the conceptacles being scattered over the surface of the frond, and not situated in the midrib.

12. Corallinaceæ, *Lamx.*

Articulated or crust-like, composed of closely compacted threads, impregnated strongly with carbonate of lime so as to be hard, rigid, and even stony. Spore-threads tufted, springing from the base of the encysted conceptacles. Purple when fresh, whitish when exposed to the air.

172. As in the preceding order, multitudes of species occur which are disguised by the immense quantity of calcareous matter which they appropriate; so is there in the florid Algæ an analogous group, which, though by no means confined to the warmer seas, abounds in them far more highly, at least as regards the number of species. In essential characters they approach very near to the following group, but are distinguished by their almost constant production of tetrasporic, instead of polysporic, moniliform threads (Fig. 48, *c*). In outward appearance, the forms which they assume are so various, that they are recog-

nised only by their calcareous nature. Some of them are mere amorphous crusts on pebbles or sea-weeds, increasing like the lichens, which they resemble, from a common centre. Others are of stony hardness, lobed and branched, like the clavate Fungi, and resemble true corals; others are filiform and repeatedly articulate, the joints often assuming an obovate form, while in others they are flabelliform and approach in character such Chlorosperms as *Halimeda*. It is not, however, every part of the plant which appropriates calcareous matter; in many there are internodes varying greatly in length, which are either entirely free, or ornamented with calcareous plates. It is through these free areolæ, probably, that water is imbibed for the purposes of nutrition. It is to be observed that what are here called spore-threads, may also be regarded as tetraspores; but I think that Dr. Harvey is quite right in his notion as to their being of the same nature with the spore-threads in the foregoing division, inasmuch as they are contained in distinct conceptacles. The subject is not, however, without difficulties, and at present has scarcely been sufficiently studied to lead to any positive results. Kützing figures, in *C. officinalis*, spores very different from the usual tetraspores, whether rightly called so or not, and indeed almost exactly like those of *Alsidium*.* Dr. Harvey figures three forms of fruit in *Corallina squamata*, representing respectively the fructification of *Jania*, *Amphiroa*, and *Corallina*, which again perplexes the subject, and makes one doubtful of the goodness of the characters on which the genera are founded. As in several other calcareous Algæ, a thin pellicle separates under the action of hydrochloric acid, marked with the hexagonal impressions of the external cells (Fig. 48, *d*).

173. The genus *Amphiroa*, which exhibits many of the more singular forms, though not found on our coasts, occurs under several species on both coasts of North America, on the east extending as high as Unalaschka and Sitcha. On our own coasts we have *Corallina officinalis* abundant everywhere, and reaching far higher northwards than *Jania*. The crustaceous species, also, whether on leaves or pebbles, or lying free at great depths

* At least in *A. tenuissimum*, Kütz., which is *Chondria tenuissima*, Ag.

in the open sea, are sufficiently abundant. *Melobesia* occurs as high as 74° N. lat.; there are, however, many genera which affect warmer seas, especially those of Australia, and they abound in the tropics. *Corallina officinalis*, as its name implies, is admitted into the Pharmacopeia on account of its calcareous nature, but there is no peculiar virtue in it which makes it superior to other similar chemical matters. Dr. Johnston believed the *Melobesiæ* to be mere states of *Corallina officinalis.*

174. I am not aware whether corallines are grazed upon by fish, as coral is by the genus *Sparus.* Mr. Darwin has described the manner in which chalk is formed in the latter case, and, from the large quantity of carbonate of lime which these plants contain, it is highly probable that they contribute their share to its formation.*

13. LAURENCIACEÆ, *Harv.*

Cylindrical or compressed, cartilaginous. Conceptacles ovate, with a terminal pore. Spores pear-shaped, radiating from a basal placenta. Tetraspores lodged in the branchlets.

175. These agree with the next tribe, *Rhodomelaceæ*, in fruit; but the frond in the greater number of species is inarticulate and solid, though sometimes tubular and septate, with the superficial cells minute, and not forming evident reticulations; the tetraspores too are scattered over the branchlets. The antheridia are highly developed, and assume curious forms, in those cases where they have been observed. Nothing can be more variable than the colour, even in the same species. *Laurencia* affords some of our commonest Algæ, and it is well known to every collector how these vary. When perfect they are of a dull purple or brownish red; but these tints pass through every shade to orange, and yellow, and green, according to the degree of their exposure, in shallow pools, or open rocks, to the action of light and air, while fresh water is rapidly destructive. Others, like *Asparagopsis*, are of a beautiful pink; while *Champia* assumes the hues of *Polysiphonia*, exhibiting, like many other Algæ, prismatic colours. The species are very widely distributed, occurring in very different localities. *Champia*, as originally understood,

* Darwin, Journal, p. 553.

is not found on our coasts. It occurs at the Cape, and in Australia, under two or three forms. But if such species as *Chyclocladia parvula* be rightly included in the genus, we have at least, on our southern coasts, one elegant representative, and an allied form occurs at New Zealand. The fruit of *C. parvula*, indeed, is at first sight like that of true *Lomentariæ*, but the placenta consists of a clathroid reticulated mass of threads, on which the spores are seated singly; while in *Champia lumbricalis* there are short necklaces of spores of a less decided pear-shaped outline. In fact, the differences are greater than exist between many genera. *Lomentaria* is well represented by the old *Fucus Kaliformis*, which sometimes grows to a large size, and *L. ovalis* is a rarer but scarcely less beautiful British seaweed.

176. In these latter genera the placenta consists not simply of a tuft of threads, but of a clathrate mass, studded with obconic spores. Without great care the nuclei may be mistaken for favellæ, to which they have at first sight a considerable resemblance. *Cladhymenia* and *Delisea* are Australian. *Laurencia pinnatifida* is the Pepper Dulse of Scotland, but certainly not so agreeable an article of food as *Alaria esculenta*, or the common Dulse. The other equally common species is probably no less wholesome, and supplies a portion of what is sold in the shops under the name of *Helminthochorton*. Both these species occur on the North American coast, the one on the east, the other on the west; and there are several other species.

177. As the antheridia of *Laurencia* attain a greater degree of complication than in the other tribes, I shall take this opportunity of saying a few words on the subject. I am not aware that any observations have at present been made which confirm theoretic notions, as to the functions of the bodies which they contain. In *Callithamnion*, *Nemalion*, *Griffithsia*, and *Ceramium*, the antheridia consist of little clusters of cells, variously arranged, in which the spermatozoids are generated. In *Wrangelia*, *Dasya*, and *Polysiphonia* they assume the form of a pod, which is filled with cells, but not, as before, naked. A near approach to this is made in

Griffithsia secundiflora, but the cells are still naked, and, according to Derbès and Solier, in an early stage there is a surrounding hyaline membrane in *Griffithsia sphærica.* In *G. Schousbœi,* on the contrary, they appear to be like those of *Callithamnion.* In *Bonnemaisonia,* again, there is at first a membrane, though at length the cells are quite free. In *Phyllophora* the antheridia are bodies consisting of two kinds of cells, and having groups of spermatozoid cells arranged in a circle round the axis, and, according to circumstances, more or less confluent. In *Nitophyllum* they form little milky spots on the surface. In *Rytiphlœa tinctoria,* they resemble those of *Polysyphonia,* except in their elliptic form; a step further, however, is made in *R. pinastroides,** where they are cellular bodies, without any investing membrane, clothed with delicate hairs. In *Laurencia* they are differently constituted in different species. In *Laurencia tenuissima,* they are curiously twisted lateral cellular plates, of a greyish tint, and bordered with large cells; the disc is occupied by the productive cells, which are far smaller than those which surround them. These evidently spring from a cellular branched axis. In *L. pinnatifida,* instead of an open plate, we have a pezizæform body beautifully figured by Greville. Its disc resembles again the hymenium of a *Peziza,* and is formed of dart-like vertical pale groups of cells, surmounted by two or three larger oily-looking sacs filled with yellow pigment. These bodies are occasionally forked, and appear to shoot out from the mass like the asci of an *Ascobolus. L. dasyphylla* presents a third modification. The antheridium is here a conceptacle, and the dart-like groups of cells are ejected from the minute terminal orifice.

178. The spermatozoids of these cells vary a little in shape.

* Greville was the first to describe these, Alg. Brit. p. 105. "In the winter months very minute, globular, shortly stalked, yellow bodies, resembling what are called the anthers in *Jungermanniæ,* form clusters upon the upper ramuli, and from their number are very obvious, as the plant is growing under water." He considers them, however, extraneous and probably of an animal nature. The septate bodies figured by Turner can scarcely be the same thing.

Derbès and Solier figure many of them with a delicate appendage, but Thuret has in vain sought for such an appearance. There can, however, be little doubt that they are truly impregnatory organs. The flagelliform appendage cannot certainly be considered as essential to their functions. They will probably be found in many other genera than those indicated by Derbès and Solier,* but their abundance in *Polysiphonia* and *Callithamnion*, and their apparent rarity in so many other cases, present great difficulties. At present it does not appear that zoospores have been found in a single genus.

14. RHODOMELACEÆ, *Harv.*

Frond areolate or reticulate, filiform or variously leafy, articulate or inarticulate. Nucleus contained in an urn-shaped conceptacle; spores radiating from a basal placenta. Tetraspores mostly seriate, in the frond or in proper conceptacles (*stichidia*).

179. The species of this division, as the name implies, often assume a very dark tint, so as to present a rich red brown rather than a florid red. They vary in external appearance very greatly; some genera, as *Polysiphonia, Bostrychia,* and *Dasya,* being composed of slender, often elegantly branched and distinctly articulated, threads; others, as *Rytiphlœa,* resembling them in form, but inarticulate, except occasionally in the alternate ramuli, while others, as *Amansia* and *Odonthalia,* have a flat and pinnatifid frond. They agree in possessing free areolate hollow conceptacles perforated above, from the base of which, short tufts of threads arise, bearing each a large obovate spore at its apex, while the tetraspores are for the most part in rows either on the distorted fronds, or in distinct elongated receptacles. They occur not only in salt or brackish water, but some of the *Bostrychiæ* are found in mountain torrents, in tropical countries, out of the reach of the spray, while others affect the brackish waters of the mouths of rivers, where they are found entangled in phænogamous plants. Many species of *Dasya, Polysiphonia,* and *Chondria* are common on our coasts, and analogous forms occur in the

* See Thuret, l. c. Derbès and Solier, Ann. d. Sc. Nat., sér. 3, vol. 14, and Supplément aux Comptes Rendus de l'Acad. des Sc. vol 1.

southern hemisphere. *Bostrychia vaga,* in the cold climate of Kerguelen's Land, may be traced from rocks and stones, about high-water mark, to a considerable distance inland. The tips of its threads are often curled, which makes them peculiarly apt to be entangled with other plants. Though *Dasya elegans* is equally common in America and southern Europe, while its near relative, *D. villosa,* abounds in Van Diemen's Land, the European *D. coccinea* is not known on the eastern North American coast; and its nearest ally is found on the Western Pacific shores, at Puget's Island, from whence it was brought by Captain Wilkes's expedition. *Rytiphlœa* is a rare inhabitant of our southern coasts. The genera are far more abundant in the southern than in the northern hemisphere. Eleven genera only occur on the eastern coast of North America, including *Chondria,* and some of them are sub-tropical, while in the Southern Ocean there are at least twenty-three. *Amansia, Alsidium, Acanthophora,* and *Digenea,* are

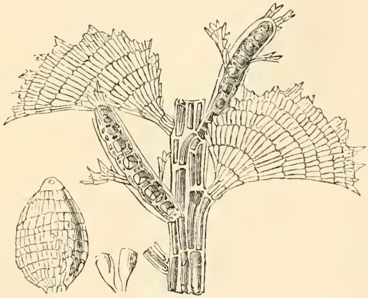

Fig. 49.

Polyzonia cuneifolia, Mont., with stichidia, conceptacle, and spores, magnified. From specimens communicated by Dr. J. D. Hooker.

unknown upon our coasts, and delight in a warm climate. They occur, therefore, in such tracts as the Red Sea; while, on the contrary, *Odonthalia* is a genus of high latitudes. Though so common in some parts of the Scottish coast, it is wholly unknown in the south of England. It descends, however, on the coast of North America, as far as lat 44° 35′. There are several beautiful forms which occur at the Cape, and in other warm seas, which are not found elsewhere ; some of them exhibiting far less conspicuously the cellular reticulation, which is so striking in most of our northern species. Amongst these is *Claudea*, the most elegant of all Algæ, of which specimens occur of extreme beauty, and a fine species has lately been added to this Australian genus. One species of *Dasya* is very remarkable, as calling to mind the genus *Bulbochæte;* and other striking cases of analogy might easily be pointed out.

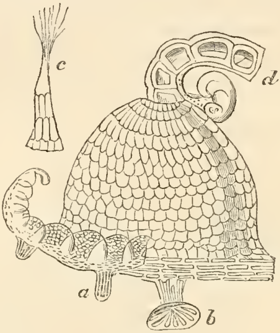

Fig. 50.

Leveillea Schimperi, Dcn.

a. Tip of shoot to show the imbrication of the leaflets, the radicles, and circinate tip.

b. Single leaflet, with an eroded tip and tubæform radicle.*

c. Tip of entire leaflet.

d. Stichidium, the tip of which is circinate, and bears imbricated leaflets, all magnified. From specimens communicated by M. Lenormand.

180. The genus *Amansia*, which has two extra-tropical species, assumes, together with *Leveillea* and *Polyzonia*, the forms of *Jungermanniæ;* and what, is very curious, in *Leveillea* the frond is circinate, throwing down roots from the midrib. They are

* Such radicles occur in *Polysiphonia*. Voyage au Pol Sud, tab. 5, fig. 2. Näg. Zeitschrift, 1847, tab. 8, fig. 18, 19.

moreover, remarkable for the beautiful reticulation of their fronds, caused by the large hexagonal cells. The species are extremely impatient of fresh water, in which they soon fade. *Digenea* is so infested with corallines, as for the most part to present very shabby-looking specimens, and to appear as if it appropriated to itself calcareous matter, which, however, is not the case. The various species of *Polysiphonia* afford beautiful objects for the microscope, transverse sections of their stems exhibiting a great variety of regular, almost geometrical, figures, from the mode in which the component tubes are arranged. Some of the *Bostrychiæ* agree with them in this structure, and in fact are scarcely distinguishable.

181. Amongst the curious forms assumed by Algæ, few are more remarkable for beauty than those which present on the one hand a clathroid, cancellated, or cribrose frond, or on the other which exhibit an open net-work. *Claudea* is a beautiful example of the cancellated frond, to which *Heringia*, a part of which only is cancellated, will bear comparison, both for beauty and elegance. *Iridæa clathrata*, Dcn., *Ulva myriotrema*, Crouan, and *Agarum Gmelini*, afford examples of

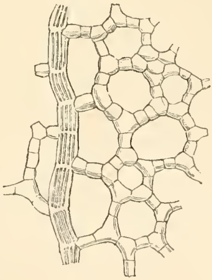

Fig. 51.

Portion of the net-work of *Dictyurus purpurascens*, Bory., magnified. From a specimen collected by Mr. Darwin.

cribrose fronds; but there are others, like *Hydrodictyon*, which exhibit the most elegant net-work. *Hanovia*, *Rhodoplexia*, *Haloplegma*,* and some others, are true or doubtful members of *Ceramiaceæ;* while *Dictyurus* is an undoubted ally of *Polysiphonia.* In this curious genus the net forms a spiral web round the principal stem, exactly after the fashion of the confluent leaflets of *Riella*, as we shall see amongst the *Hepaticæ.*† It will be seen, from the figure, that the branchlets from which the net-work grows are precisely like those of *Polysiphonia.* These plants are simply beautiful objects, of no practical utility.

182. Under the head of Chlorosperms, I took occasion to speak of the variations to which many of the species are subject. These, however, are few in comparison to what take place among Rhodosperms. One species alone, *Gelidium corneum*, varies to such an extent that the forms may not only be considered as distinct species, but even as belonging to different genera. In point of thickness and degree of division of the frond, the limits are almost boundless, but the fruit always remains essentially the same, though the position sometimes differs, as in *Odonthalia dentata*, where it is axillary or marginal, and this applies to either kind of fruit. On the contrary, there may be great similarity of frond, with a total diversity of structure; and characters of habit are sometimes extremely deceptive. The limits of species are no less vague amongst the filiform than the more frondose Algæ, and it is not every difference of the arrangement of branchlets that must be considered as of specific importance.

183. There are many circumstances which have great influence on the form of Rhodosperms as upon other Algæ. Comparative depth, difference of temperature, the quantity of saline matter contained in the water, exposure to the action of currents, and many other points, operate in effecting changes of more or less gravity. Almost every species of Rhodosperm varies more or less, as indeed is the case with all vegetable productions, and characters which are most relied upon sometimes fail unexpectedly. *Nemaleon multifidum* is often perfectly

* Decaisne, in Ann. d. Sc. Nat. sér. 2, vol. 2, p. 233.

† In *Thalassiophyllum Clathrus*, the leafy expansions are spirally developed round the branching stipe.

simple, when it is not to be distinguished from the Mediterranean *N. lubricum*. *Delesseria alata* is sometimes quite destitute of margin, when it becomes *D. angustissima*. Several species, which in the ordinary condition have the tips of the fronds perfectly straight and even, occasionally produce hooked clasping tips. *Cystoclonium purpurascens*, produces such a variety on our coasts, when it looks like a *Hypnea*, to which genus it has consequently been referred, and *Delesseria lacerata* sometimes forms an inextricable mass of intricate fronds, attached to each other so closely that they cannot be separated without rupture.

184. The causes which produce such changes are in general unknown, though sometimes we have a slight clue to variations. *Chondrus crispus*, when exposed to the fresh water of the estuary, acquires great thickness and breadth ; while at low-water mark it is thin with forked narrow branches.* Multitudes of intermediate forms occur of great variety of outline and thickness, so that in these respects and general habit it almost rivals *Gelidium corneum*. *Dumontia filiformis* becomes singularly crisped and thick, where a strong tidal current comes down, instead of having tolerably even slender tapering branches. *Dasya coccinea* in deep water seldom produces fruit, and is very irregularly branched. The squarrose variety, which is obtained by dredging, has most of the branches set on at a right angle, so as to make it appear at first sight totally different. Intermediate forms, however, are found by dredging on different bottoms, which afford a complete connecting series.

185. In some cases, where the circumstances appear just the same, one species uniformly replaces another without any intermixture, *Callithamnion spongiosum*, for instance, takes the place of *C. arbuscula* on shores where the latter is not found,

* Some species of Algæ, as *Bangia atropurpurea*, grow indifferently in fresh and salt water, without any perceptible diffrence. The nearly allied Bangioid form of *Porphyra vulgaris* is most permanent where it is very near high-water mark, and therefore gets less nourishment. It is evident, however, that the largest forms of true Rhodosperms do not uniformly occur where they are most constantly immersed.

these plants never growing together, though both affect similar situations on different shores (Harv. Phyc. Brit. tab. 125). It is not, however, supposed that they are mere forms of one species.

186. Though Algæ in general derive their nutriment from the surrounding medium, cases occur in which the substance on which they grow seems to have some influence. *Delesseria alata*, and its form *angustissima*, grow together on the same stem of the digitate *Laminaria*, but this same matrix, in other cases, apparently exercises considerable influence on the plants which grow upon it. *Polysiphonia urceolata*, for instance, when growing upon rocks exposed at low water, is more robust and much more branched than when it grows on *Laminaria digitata*, in which case the branches are shorter, their ramuli squarrose, and often turned back. *Rhodymenia palmata*, on rocks, is broad and but slightly divided, on *Fucus serratus* it assumes the laciniate form of *R. sobolifera*.

187. Where there is any doubt as to specific identity, the first point is to ascertain the fruit which in general does not vary in the same species. In *Corallina squamata*, however, as already mentioned, so great a diversity exists as to render received opinions, as to the value of the fruit in that group, very doubtful. All characters, on the contrary, which depend on mere outline, on the degree in which the fronds are cleft, comparative thickness, &c., are to be received with great caution, even in specimens from distant localities; the disposition of the fruit, on the contrary, its intimate structure, and that of the frond, are in general points of great importance.

188. In many cases, finally, differences which at first appear specific, depend merely on age. The old emarginate leaflets of *Leveillea Schimperi* (Fig. 50), for instance, are very different from the acuminate form of these organs when young, with their flagelliform terminating threads. The older frond, also, may be much less simple in structure than the younger, from the addition of superficial cells. But these are points which will be readily appreciated by every attentive observer. The reproach which was cast upon Algologists a very few years

since, is now in great measure removed, and, with few exceptions, they are ready to recognise the importance of something more than a superficial examination. There must, indeed, be something subjective, as well as objective, in all successful study of nature.

III. MELANOSPERMEÆ, *Harv.*

FUCOIDEÆ, *Ag.*, *J. Ag.*—ALGÆ APLOSPOREÆ, *Decaisne.*—PHYCOIDÉES, *Mont.*

MONŒCIOUS or diœcious. Spores olive, arising singly in fours or eights from the endochrome of the fertile cells of proper conceptacles, or zoospores resembling spermatozoids, which are constantly produced in some genera.

189. As regards size and general importance, were they paramount in inquiries as to comparative dignity, the grand division at which we have now arrived would certainly entitle many of the productions which it comprises, to a pre-eminent place amongst Algæ. It would, however, be difficult to show any points of structure, or any complicity or perfectness of transformation, in the component parts, which would entitle them to pre-eminence above many of the Rhodosperms. It is true, indeed, that Thuret has ascertained by actual experiment, that the spermatozoids are really efficacious in promoting the growth of the spores; but Pringsheim has shown the same in *Vaucheria*, and so few experiments have at present been made that we cannot, under our existing state of knowledge, pronounce that these bodies are merely representative in the other division. Besides which, no one would contend that the nobler Cryptogams are higher in the order of vegetables than Phænogams, because impregnation is effected in them by spermatozoids, while in Phænogams the fovilla alone of the pollen tubes seems efficient.

190. As in the other two divisions, there are species of a

very simple structure, though evidently connected in an unbroken chain with others which form submarine forests, and vie in habit with many a Phænogam, and in some cases exhibit an approach to exogenous growth.

191. In this division, as in the last, it is possible that certain of the lower cellular forms of Algæ, as well as the filamentous, may really, in a truly natural system, be entitled to a place here; but, inasmuch as artificial distinctions are inseparable from any systematic arrangement, even though we might have a glimpse of the truth ourselves, it would, probably, be impossible to put it forward in such a shape as to be practically useful. In the present condition of Algology, a large number of those species which have been sufficiently studied in their place of growth, are known to be either monœcious or diœcious, and the day is probably not far distant when even amongst the simpler Algæ, spermatozoids, or their representatives, will be found to prevail universally. I say representatives, because in many Melanosperms there are two kinds of zoospores produced in different organs, both of which are fertile, and the genus *Cutleria* seems to lead directly to these, in which, though two kinds of bodies are produced, absolutely similar in form, though not in size, to those of *Stilophora*, one only has at present been ascertained to be fertile. The reproductive body here is a zoospore, and it is probable that the other body is a spermatozoid.* If not a true spermatozoid, then, it is at least representative.

192. Melanosperms occur in all parts of the world. *Scytothalia Jacquinotii*, and *Adenocystis Lessoni*, attend *Iridæa micans* in Cockburn Island, while *Desmarestia aculeata*, and *Laminaria saccharina* extend as far as 73° or 74° N.L. If the higher parts of the Northern Ocean abound in *Laminariæ*, the warmer seas support multitudes of *Sargassum*, while the southern have their species of *Macrocystis*, *D'Urvillæa*, and *Lessonia*, and in all parts alike the larger mass of seaweed belongs to Melanosperms, though the Rhodosperms and Chlorosperms may number more species.

* Thuret, l. c. vol. 14, tab. 31; vol. 16, tab. 1.

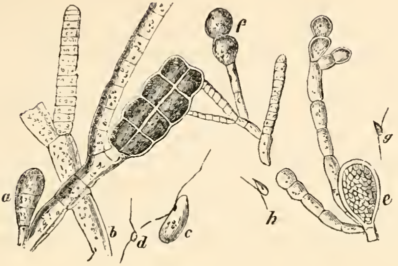

Fig. 52.

a. Cutleria multifida, fruit with 8 cells, producing large zoospores.
b. Fruit with 32 cells, producing spermatozoids.
c. Zoospore.
d. Spermatozoid.
e. Oosporangium of *Stilophora rhizodes.*
f. Trichosporangium of ditto.
g. Small zoospore from Oosporangium.
h. Larger zoospore from Trichosporangium.
All magnified, after Thuret.

193. The divisions into which this great class naturally breaks up are the following: *Ectocarpeæ, Chordariæ, Dictyoteæ, Laminariæ, Sporochnaceæ,* and *Fucaceæ,* of which a tabular view is subjoined.

MELANOSPERMEÆ.	Articulate.	*Ectocarpeæ.*—Filiform. Spores or cysts external.
		Chordariæ.—Cylindrical, threads interlaced. Cysts immersed.
	Inarticulate.	*Dictyoteæ.*—Spores or cysts superficial, collected in little definite patches (*sori*).
		Laminariæ.—Spores or cysts dispersed in indefinite patches, or covering the whole surface.
		Sporochnaceæ.—Cysts attached to external threads, which are free or conglobated.
		Fucaceæ.—Spores on the walls of globose cavities or conceptacles.

1. Ectocarpeæ, *Ag.*

Filiform, articulated; spores or cysts external, sometimes formed by the swelling of a branchlet.

194. We begin with the simplest forms, in which the frond is composed of a single simple or branched thread, or coated with cells, or very rarely solid and cellular below, giving off sub-globose spores or cysts filled with a dense endochrome, and active granules contained in distinct organs. There is some doubt about the nature of the former, whether they are simple or compound organs, unless indeed *Ectocarpus sphæricus,* D. and S., in which the globose lateral cysts were observed to give rise to active bodies, be considered decisive of the point. As regards the podlike organs, Thuret has shown, beyond all question, that their office is to produce zoospores, and analogy would lead us, even apart from *E. sphæricus,* to suppose that the endochrome of the other bodies is resolvable into zoospores of another order, as in *Ulvaceæ.* Be this as it may, the two organs are for the most part seated on distinct individuals, and it is probable that all the siliculose *Ectocarpi* are mere

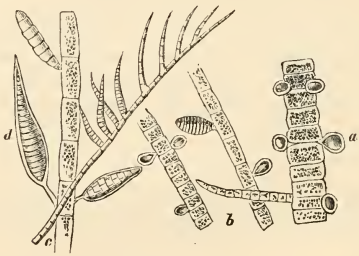

Fig. 53.

a. Ectocarpus sphærosporus, Carm. From a specimen communicated by Mr. Ralfs.

b. E. pusillus. From specimens gathered by Mrs. Griffiths. Both kinds of fruit appear on one of the threads.

c. E. fenestratus, B. From specimens sent by Mrs. Griffiths.

d. E. fasciculatus and silicule. From specimens sent by Mr. Ralfs. All more or less magnified.

conditions of sphærical-spored species. In *E. pusillus*, both spores and silicules are produced upon the same thread.

195. As regards geographical distribution, they are abundantly scattered throughout the temperate regions of the northern hemisphere, both on the British and American coasts, but they occur also in the Mediterranean; and some of the northern species appear again in the southern hemisphere, as at Cape Horn and New Zealand.

196. *Ectocarpus*, which abounds in species, is remarkable for the variety of forms under which the zoosporic fruit appears, affording a number of beautiful microscopic objects, and strictly defining species which would otherwise be unintelligible. In most species of *Ectocarpus* the threads are distinct, but from their flaccid nature they easily become entangled, and in consequence one or two species form spongy ropes, which give them a peculiar character. This condition is not, however, essential. While *Ectocarpus* is distinguished by the flaccid filaments, for the most part irregularly branched, and very seldom putting on any neat or delicate forms, *Sphacelaria* is, on the contrary, distinguished by rigid threads, often of exquisite symmetry, simulating various higher Cryptogams. One of the species peculiar for its abundant racemose fruit has been found only once, a singular instance of the combination of more simple stems than usual, with more highly developed fruit. It is principally a northern genus; but three or four species occur also in the south. *S. scoparia*, indeed, appears almost cosmopolitan. To these genera, others succeed with solid stems. *Chætopteris* is distinguished by this character alone from *Sphacelaria*. *C. plumosa* has its southern limit about the south of England, while it extends northward to Greenland and the Arctic Seas. The only remaining species belongs to the southern hemisphere. *Cladostephus* has the stem and main branches inarticulate, while the ultimate ramuli resemble in structure the lowest form of Melanosperms. The two common British species, easily known by their densely crowded or verticillate branches, so as to make them resemble little bottle brushes, occur also on the North American coast, and there are one or two species of warmer climates.

197. Some authors separate *Ectocarpi* from the more compound species; but we have before seen amongst Rhodosperms, that even in the same genus great differences exist in this respect, and, taking all circumstances into consideration, I think that Dr. Harvey is quite right in keeping plants together so clearly associated by nature.

2. CHORDARIÆ, *Harv.*

Frond compound, gelatinous, consisting of vertical and horizontal threads, variously interlaced. Cysts contained in the substance of the frond, attached to the horizontal threads, giving rise to zoospores.

198. The preceding group was remarkable for containing both highly rigid and extremely flaccid species, but in both cases devoid of gelatine, or, if not absolutely so, containing so little as to present no salient character. The contrary is eminently the case with most of the tenants of this division, though connected with *Ectocarpeæ*, by species in which the character is of no prominence. In some species the threads are distinct above, though rising from a common cellular parasitic base, while in others they are felted into a more or less compact mass, varying from an adnate stratum to globose tuberous bodies, and thence to a branched or simple slimy cord, often many feet in length. The fruit, in most cases, is twofold, consisting either of oblong cysts, or elongated and often septate pods, both of which produce zoospores; but sometimes in the one, sometimes in the other, alone they have been seen to germinate; sometimes both are equally fertile. The species, for the most part, are inhabitants of northern climates, and more abundant in colder waters, though not confined to them, and two of our commonest species, *Leathesia tuberiformis* and *Chordaria flagelliformis* are equally common in the southern hemisphere. The most curious group, perhaps, is that of *Elachistea*, the species of which are parasitic on various Algæ, and in some cases, as in *Himanthalia lorea* and *Elachistea scutulata*, the connection between the tissue of the matrix and the base of the parasite is so continuous as to have induced a belief that the species are merely abnormal developments of cellular tissue. Such notions might,

perhaps, be entertained were there no proper fruit; but when this is frequently of two kinds, and totally different from that of the matrix, and there are, moreover, many closely allied Algæ which are not parasites, the belief is as absurd as that of the supposed identity between the myriads of truly parasitic fungi, and the plants on which they grow. *Myrionema* presents a genus still less organised than *Elachistea,* and by reason of the difference of colour between the brown threads and the red or green matrix the distinction is more evident. These parasites all belong to the north hemisphere. *Elachistea* extends as far south as the Canaries. *Ralfsia* forms a lichenoid crust on pebbles, resembling in colour the more tawny *Zonariæ.* The fruit is of rare occurrence, and approaches closely in character to that of *Elachistea,* growing, in fact, in tufts much after the fashion of that genus. *Leathesia* occurs in every part of our coast, attached to corallines, shells, rocks, &c., either forming gelatinous pulvinate crusts, or tuberlike more or less inflated masses. Different as this genus is in external habit, it is almost identical, in point of structure, with *Mesoglœa,* which with *Liebmannia* forms filiform branched slippery masses, composed of central articulated threads beset with myriads of branchlets, consisting in great part of moniliform filaments. Most of the described species belong to the Atlantic; but Port Natal and the Philippines have their representatives. The Philippine plant, at least, which I have examined, is quite certain. *Chordaria* is merely a compact form of *Mesoglœa,* but still of a strikingly gelatinous consistence. In several of these plants the joints of the external threads increase in diameter as they approach the surface, and are less subject to the pressure of contiguous threads, and in such cases the endochrome is generally more highly coloured and more copious (Fig. 54); but such appearances are not to be mistaken for fruit, which is often very distinct, and sometimes of two forms, where the external cells are much developed, as in *Liebmannia.* In no plant is this more marked than in *Chordaria divaricata,* the terminal joints alone being globose.

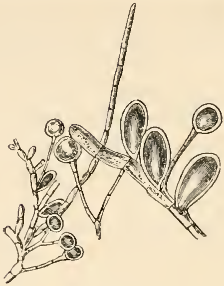

Fig. 54.

Threads and cysts of *Chordaria divaricata*. Magnified. From specimens communicated by Dr. Harvey.

3. DICTYOTEÆ, *Grev.*

Frond mostly flat, sometimes cylindrical; surface reticulated. Spores or cysts external, collected in little patches.

199. We have here an assemblage of coriaceous or membranaceous Algæ, the surface of which is sprinkled with groups of naked spores or spore-cysts. The endochrome is usually entire, but sometimes it is quadripartite, and sometimes the divisions are eight in number. In one of the genera only, anything like antheridia has been observed, and there is reason to believe that in *Cutleria* at least the contained bodies may possibly have the power of impregnation. The zoospores in the quadripartite endochromes are very large, of a dark colour, and have two lateral threads, while the bodies in the filiform multiseptate antheridia, seated variously on the tufted threads, are far more minute, pale, but with similarly situate appendages (Fig. 52, *a*, *b*, *c*, *d*). A few species occur on our coasts, and they are not more numerous on the coasts of North America; several are found in the Mediterranean and other warmer seas, and they are characteristic rather of tropical and sub-tropical seas, where they obtain their maximum of development. *Padina Pavonia* is common in the south of England, but does not extend far north, and on the American coast it com-

mences at a far lower latitude. It is found, too, in the Pacific and Indian Oceans. The species of *Dictyota*, on the contrary, are extremely abundant northwards, being very common on the greater part of our coast; but they are found in far distant realms. *Haliseris* is a deep sea genus, as far as our own Nereis is concerned, but there are many representatives in warmer climes. The greater part of the species have a decided midrib, which gives them a peculiar Fucoid appearance, very different from that of their allies. Numerous genera are described, most of which are represented on our coasts. The first, however, to be noticed, *Hydroclathrus*, though occurring in the Mediterranean, is wholly unknown in the British Isles. The fronds, which are very irregular in outline, form wide spreading patches, adhering by their lower surface, and laterally confluent. The young fronds are pierced with round holes of small size, and somewhat pressed together; but as the membrane expands, the holes expand also, and new ones are formed in the interspaces, until the whole membranous wall of the baglike body is converted into a delicate lacework, the margin of each hole being involute, so as to look like a distinct rim. It is found in various localities, extending as far south as Mauritius and New Holland, whence I have specimens. Dr. Harvey's figure resembles closely a group of *Cyttaria*, a fungus to which we shall have occasion to advert hereafter. *Asperococcus* and *Punctaria* are, to these Algæ, what the larger *Enteromorphæ* and *Ulvæ* are to Chlorosperms, being yellow-brown sacs or laminæ studded with fruit, while *Striaria* and *Dictyosiphon* represent the branched and almost filiform *Enteromorphæ*. With *Stilophora*, we arrive at species with a solid or imperfectly tubular frond; *Dictyota* commences the Zonarioid group. The structure of this common genus is very curious. "Every lacinia of the frond terminates in a single cell, by the constant division of which at the lower side the other cells of the frond are formed, the terminal cell being thus continually pushed onwards" (a mode of growth precisely like that which obtains in the increase of exogenous stems). "Hence it results that the longitudinal lines of superficial cells, which in the flabellate genera diverge from one another, in this converge; thus affording a ready method of ascertaining the genus in default of fructification." Harv. Mel. p. 100.

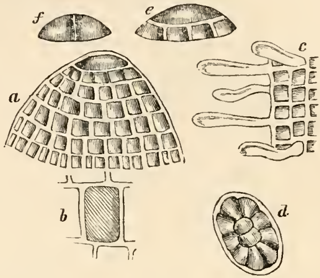

Fig. 55.

a. Tip of young frond of *Dictyota dichotoma.*
b. Cell showing spiral structure.
c. Threads produced from marginal cells in young fronds.
d. Sorus of spores.
e. Terminal cell in act of division.
f. Ditto with a view to make two new centres of growth.
All magnified.*

Zonaria affords the well-known Turkey feather or Peacock's tail laver of our southern coasts and of North America. The species are generally remarkable for their wedgeshaped fronds,

* I do not find the division of the cells as regular as figured by Nägeli, (Die neuern Algensysteme, tab. 5, fig. 10—21,) who makes each circle of cells increase in geometric progression, nor do they all grow in regular lines. Great differences, in this respect, will be found in different specimens, or in different parts of the same specimen. Nägeli was, however, the first to show the mode of growth. When the frond becomes forked, the terminal cell divides longitudinally, and then each half cell grows according to its own law. As the base of the new cell assumes a circular outline, the cells which rise from its concentric and radiate division assume also a circular disposition, being as it were meridians of latitude to the meridians of longitude. The frond of *Dictyota* is peculiarly liable to be infested with species of *Cocconema,* which under a low magnifier look like little plant-lice. The calcareous Algæ are also liable to the same affection.

which are often concentrically zoned, and resemble variegated feathers, a resemblance which is so much the greater in consequence of the beautiful fringe of hairs with which each band is ornamented. Parallel, or rather concentric with the spores, is a row of articulated threads, which have a strong resemblance to the elongated processes which contain the spermatozoids in *Cutleria.* They are indeed so like them, that in a plant so closely allied it is impossible not to suspect similarity of function. The endochrome is figured by Harvey as dividing into four distinct spores. *Taonia* departs somewhat from the wedgeshaped outline, differing at the same time in the details of fructification. *Cutleria* has a flat multifid frond of a tawny hue, with large fruit. The highest degree of development is reached in *Haliseris,* which has a flat linear membranous forked frond, threaded by a cartilaginous midrib. It is in species principally of *Zonaria, Padina,* and *Haliseris,* that the tropical and sub-tropical seas attain their maximum of species. I am not aware that any are of practical utility.

4. LAMINARIACEÆ, *Grev.*

Inarticulate, mostly flat, often strapshaped. Spores superficial in indefinite patches, or covering the whole frond.

200. The plants of this order attain frequently a very large size, and are known by the mostly coriaceous fronds, and fibroso-cellular consistence, and fruit which is dispersed in irregular superficial indefinite patches or covers the whole frond. The frond itself is tubular, divided into chambers by transverse partitions, or flat and solid, often entire, but sometimes pinnatifid, sometimes divided into straplike lobes, and in some cases increased by repeated fissures upon a given normal system. In general there are no bladderlike inflations, but occasionally there is one or more at the base of every frond. In some the frond is regularly cribrose, and in more than one the edges are highly curled and plaited. The stem is sometimes absent, but is mostly of large dimensions, generally simple, but sometimes repeatedly divided.

201. In many perennial species, the stem increases in size year by year, a new frond springing from its apex, and replacing the old one, which at last separates from the point of

juncture with the new frond, to which it is attached, till it has attained its normal form or dimensions. The fruit consists of incrassated cells springing vertically from the frond, the endochrome in some cases being finally quadripartite. Thuret,

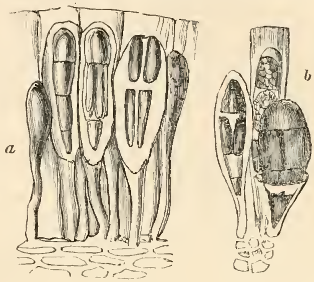

Fig. 56.

a. Quadripartite endochromes of *Lessonia nigrescens.* Magnified.
b. Ditto, in *Ecklonia flabelliformis*, J. Ag.
Both from drawings by Dr. Hooker.*

however, figures zoospores as produced from the endochrome, but whether in essentially distinct cells or not is, perhaps, doubtful. Harvey speaks both of spores and antheridia, but on what grounds I do not know.† It should be observed, moreover, that Thuret has proved the zoospores to be reproductive in *Chorda lomentaria, Chorda filum,* and two *Laminariæ.* There is therefore no reason for supposing that real spermatozoids exist in this division, though it affords another instance of a binary mode of propagation.

202. Of the two main divisions of this order, viz., those with definite leaves, and those which have a frond which is a mere

* I have also, from the same quarter, drawings of quadripartite endochromes in *Ecklonia biruncinata* and *Alaria Pylaii.* They are to be found also in some of the *Laminariæ* of our own coasts. Dr. Montagne was the first observer of the quadripartite spores in *Ecklonia runcinata.*

† Dr. Harvey says that in *Chorda filum* there are mixed with the vertical spores numerous narrow elliptical transversely striated cells, which may be antheridia. Thuret, as stated in the text, has recorded the germination of the minute zoospores in this species.

expansion of the top of the stem, or which is simply cylindrical, the former consists of species which inhabit the southern seas and tropical regions, while those belonging to the latter are eminently plants of northern latitudes, their maximum being attained on the coasts of North America. On our own coasts the *Laminariæ*, which are all inhabitants of tracts exposed only at low tides, compose, perhaps, in point of mass and volume, the larger part of our Algæ, even including the Fuci. Individuals of *L. bulbosa* occur, which are a sufficient load for a man. On our own coast they attain many feet in length. In the other division, however, the length is sometimes counted by hundreds of feet. Indeed, from the mode of formation there is no limit, except such as may be placed in the natural decay of the older portions.

203. But, perhaps, the genus *Nereocystis* is the most wonderful of all, whose stem occasionally attains a length of 300 feet, though extremely slender even at the top, where it is surmounted by an enormous floating bladder six or seven feet long, affording a favourite resting-place to the sea otter. The account, indeed, is apparently so fabulous as given by Mertens, in an interesting paper on the botany of the Russian possessions in America, that it could not be believed did it not depend upon unquestionable authority. The filiform stem, which is about as thick as packthread, when two or three feet long, swells suddenly above into a globose bladder. From the top of this springs a tuft of geminate leaves, mostly rising on five petioles. These leaves are lanceolate and membranaceous, from one to two feet long, and two inches broad in the centre. As the plant grows older, the stem increases enormously in length, but only slightly in thickness. The globose bladder swells into a turnip-shaped or retort-like cylinder, six feet long, and four feet six inches or more in diameter in the widest part, the lower extremity gradually passing into the stem. The leaves, which at first were marked with a few faint nerves, split in their direction, and cover a large space by their entangled mass, and attain a length of twenty-seven feet or more. Where the plant grows in any quantity, the surface of the sea becomes impassable to boats, in consequence of the dense floating masses of vegetation. The

stem is employed for fishing-lines when dry, and the large cylinder is used as a siphon for pumping water out of their boats, in the same way in which *Ecklonia buccinalis* is frequently used at the Cape. *Alaria esculenta* has already been noticed more than once as affording acceptable food, the part consumed being principally the fine but delicate midrib, and the lateral appendages which bear the fruit, and which give rise to the familiar name of the plant in Scotland, viz., Badderlocks.* The stems of *Ecklonia buccinalis* are used as mentioned above, and are also formed by the Cape herdsmen into rude trumpets. Our own species abound in Kelp, and form a large portion of the manure which is collected on the south eastern coasts of England. Twelve genera are enumerated by J. Agardh, of which three belong to the leaf-bearing division. Of the first two, *Adenocystis* and *Scytosiphon*, or *Chorda*, in which the whole tubular frond is covered with fruit, the latter only occurs on our coasts; the former is a South Sea plant, and differs from the other in its saccate form. *Chorda filum* is remarkable for the great length to which its threadlike stems extend, which make them, when dry, like *Nereocystis*, fit for fishing-lines. In passing through the Sounds of the western islands, as between Kerrera and the Mainland, they have a very striking appearance in the clear water, as they lean in the direction of the tide, their surface being sometimes clothed with delicate colourless filaments. *Laminaria* contains something under twenty species, of which a few have the habit and size of *Punctaria*. Most of the finer species grow on the north eastern coast of Asia. To this succeed the old *Fucus bulbosus* and *Clathrus*, of which the former is a well-known inhabitant of our coasts, and the latter is remarkable for its perforated frond. *Alaria* is one of the great ornaments of our northern seas, for its beautiful costate frond, and singu-

* This seaweed is certainly relished on the western coast of Scotland. I have known peasants bring it over from the Isle of Mull to the mainland, as an agreeable present to their friends. The Rev. A. W. Brown suggests that the term Badderlocks is a corruption of Balderlocks. See Thorpe, Northern Mythology, vol. i., p. 22. The name Murlings alludes, probably, to the membranous frond.

lar lateral appendages. In this species and some others, as *Alaria Pylaii* and *Laminaria reniformis,* there is a very beautiful hexagonal tissue, remarkable for its extremely thick lining substance, which in some cases almost obliterates the cavity. I have observed it in *Alaria esculenta,* but it is much more regular in the two species above mentioned, as appears by sketches from Dr. Hooker now before me. *Ecklonia,* unlike *Laminaria* and the genera formed from its species and their allies, is essentially a genus of the south, though one species ascends as high as Spain and the Canaries. The frond is pinnatifid, the pinnæ arising from the evolution of the marginal teeth. The stem of *E. buccinalis* is three to four inches thick, and strongly inflated above.

204. *Thalassiophyllum Clathrus* is one of the most beautiful productions of the sea, and, like so many other fine allied seaweeds, is a native of the Russian coast of North America. "It is generally about the height of a man, very bushy and branched, each branch bearing a broad leaf at its extremity, which unfolds spirally, and by this gradual development produces the stem with its branches and lateral divisions. A spiral border wound round the stem, indicates the growth of the frond. The frond presents a large convex bent lamina without nerves; or a leaf of which one half is wanting, for the stipe may be considered as an excentric nerve. A number of rather long narrow perforations, arranged in a radiating form, gives it the appearance of a cut fan; these foramina being coeval with the formation of the frond, and apparently not owing to inequalities of substance."*

205. *Costaria* contains one, or perhaps two, remarkable species, differing from *Laminaria,* in having from three to five ribs radiating from the tip of the stem, and running almost parallel, like those of many endogens. This genus, as far as is at present known, is confined to the north-west coast of North America. The *Lessoniæ* (Fig. 16) are amongst the most wonderful Algæ, being, in fact, large dichotomous trees, with leaves growing above, and hanging down one to three feet

* Mertens, l. c. See Hook. Bot. Misc., vol. 3, p. 6; Linn., v. 4, p. 49

in length. The trunks are some five or ten feet long, and a foot thick. Their roots are never bare at the lowest tides, but the leaves are seen floating on the top of the water, or the topmost branches projecting above its surface. "To sail in a boat over these groves on a calm day," says Dr. Hooker, "affords the naturalist a delightful recreation, for he may here witness in the Antarctic regions, and below the surface of the ocean, as busy a scene as is presented by the coral reefs of the Tropics. The leaves of the *Lessoniæ* are crowded with *Sertulariæ* and *Mollusca*, or encrusted with *Flustra*; on the trunks parasitic Algæ abound, together with Chitons, Limpets, and other shells; at the base and amongst the tangled roots swarm thousands of *Crustacea* and *Radiata*, while fish of several species dart amongst the leaves and branches. But it is on the sunken rocks of the outer coast that this genus chiefly prevails, and from thence thousands of these trees are flung ashore by the waves, and with the *Macrocystis* and *D'Urvillæa*, form along the beach continued masses of vegetable rejectamenta, miles in extent, some yards broad, and three feet in depth; the upper edge of this belt of putrifying matter is well in shore, whilst the outer or seaward edge dips into the water, and receives the accumulating wreck from the submarine forest, throughout its own length. Amongst these masses the best Algæ of the Falklands are found, though, if the weather be mild, the stench which resembles putrid cabbage is so strong as to be almost insufferable. The ignorant observer at once takes the trunks of *Lessonia* thus washed up for pieces of driftwood, and on one occasion no persuasion could prevent the captain of a brig from employing his boat and boat's crew, during two biting cold days, in collecting this incombustible wood for fuel."

206. The resemblance, however, to woody stems is not entirely confined to the external aspect, because a cross section exhibits rings of growth. A figure has already been given of this structure at p. 56, but the mode of increase is not at present certain. It is remarkable that the stem of *Laminaria*, which periodically casts its frond, and that of *Lessonia*, in which the frond seems to increase by longitudinal division,

during the whole period of its existence, should increase in a different way, the one from below, upwards, according as the roots increase,* while *Lessonia* increases from above, downwards, as the leaves increase. The latter, therefore, is in another respect analogous to Exogens.†

207. As increase in *Lessonia* takes place by the constant division of a flat leaf, the basal portion of which becomes the petiole, and ultimately swells into a branch, the stems have always a more or less elliptic form, and their section exhibits an elliptic core. This form of the core is not, however, peculiar, but exists equally in many other Algæ. It is probable that *Lessoniæ*, though attaining so large a size, are really of very rapid growth.

208. *Macrocystis*, which occurs under a large number of modifications, forms, like the *Laminariæ* of northern climes, the outer belt of vegetation, and seems incapable of flourishing without a depth of some six fathoms. A slender stem proceeds from a branched root, as in other *Laminariæ*, bearing at its tip a lanceolate or oblongo-lanceolate frond. This divides at the base, the fissure extending upwards, so as to form two petioles, each of which swells into an oblong or pyriform cyst. Another fissure is formed in a similar way a little above, and so on, till a single frond may at the same time have eight or ten fissures, each of which will ultimately gain the common apex. The margins of the fissures are at first perfectly even, but they soon become ciliate like the outer edge. The continuity with the base is ultimately broken, and, the division going on indefinitely, the whole reaches a length of hundreds of feet, forming enormous masses, which are wafted about by the waves. The most singular fact is, that fructifi-

* Mr. G. H. Hoffman has, at my request, examined fresh specimens of *Laminaria digitata*, and confirms Schultz's account in every essential point. I have had no opportunity of observing for myself since the publication of Schultz's paper.

† *Ecklonia buccinalis* exhibits similar rings of growth, with an orbicular central pith, as appears from an original drawing, by Dr. Hooker, now before me. In *Lessonia Sinclairii*, from California, though the stem is cylindrical, the pith is elliptic.

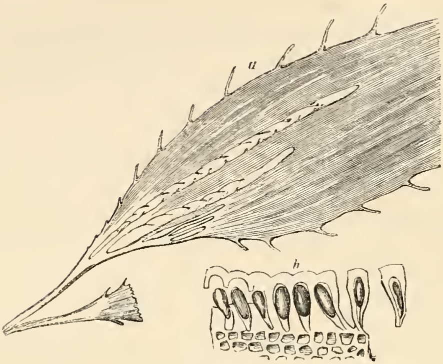

Fig. 57.

a. Young frond of *Macrocystis pyrifera*, showing the mode of increase. From a specimen gathered at Table Bay by Dr. Harvey.

b. Fruit of *M. pyrifera*, var. *luxurians*, magnified, showing the spores and their cells separating in different ways. From a sketch lent to me by Dr. Hooker. The quadripartite division does not appear in this section, but Dr. Hooker has observed it in others.*

cation is only found in young plants, and consequently in such as are attached to their native rocks. There the seeds will find objects on which they may be attached, but it is evident that they would be perfectly useless in the wide seas, a thousand miles or more from land, and with a depth of a thousand fathoms below them. The seaweed prairies of the tropics are formed by species of *Sargassum*. "*Macrocystis* girds the globe in the southern temperate zone, but not in the tropics or the northern hemisphere."

5. Sporochnaceæ, *Harv.*

Inarticulate; spores produced in jointed filaments, which are free or compacted into little knob-like masses.

209. A small tribe consisting of a few olivaceous seaweeds,

* A young specimen from the Falkland Islands in fruit, given to me by Dr. Hooker, is at first repeatedly dichotomous.

which change to a verdigris green when exposed to the atmosphere. The spores are sometimes the metamorphosed joints of scattered threads, but frequently the threads are compacted into distinct receptacles. The species are perhaps less known than some others as regards their fruit, from their being deep-sea plants, and therefore only obtainable in a good state by dredging. There has been a good deal of discussion as to their affinity, but if the larger species be considered, there is but little doubt that they are rightly placed here.

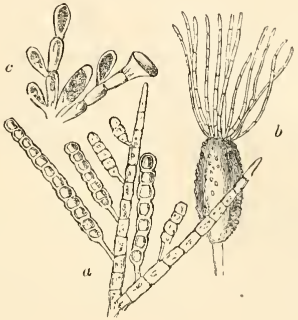

Fig. 58.

a. Spore threads of *Arthrocladia villosa*, magnified.

b. Pedunculate receptacle of *Sporochnus pedunculatus*, ditto.

c. Spores on the threads from the receptacle.* Both from specimens dredged at Weymouth.

Many of the species produce tufts of delicate filaments, which have, however, nothing to do with the fruit. The same species varies singularly in breadth, the extreme forms being so

* It will be observed that the threads are sometimes terminated with a swollen sub-pileiform cell much after the fashion of *Carpomitra Cabreræ.*

different as to seem to indicate totally distinct species. They are indifferently Algæ of the northern and southern hemispheres; and some species, as *Dichloria viridis* and *Desmarestia ligulata*, are found in both. Of our British species, *Arthrocladia villosa* extends as high as Scotland, but *Sporochnus pedunculatus* and *Carpomitra Cabreræ*, a very rare if a true inhabitant of our seas, are southern plants.

210. They form two evident groups distinguished by the freedom or compactness of the fruit-bearing threads. The antennæ-form threads of spores in *Arthrocladia* are very beautiful. In *Desmarestia* the fruit at present is unknown, though some of the species are extremely common. In the broader forms of *D. ligulata*, the fronds are distinctly nerved, and sometimes resemble leaves, in consequence of the secondary nerves, as in that found at Loch Swilly. *Chnoospora*, which is essentially tropical, is remarkable for its dichotomous fronds. None of the species of the second group have at present been found in America; but dredging may yet detect individuals which have hitherto escaped notice. Few Algæ are more beautiful than *Sporochnus pedunculatus*, when the pear-shaped fructifying branches are terminated by their tufts of threads. The mitræform receptacles of *Carpomitra Cabreræ*, situated at the tips of the branches, give a singular appearance to the frond, from the peculiar way in which they are seated. *Arthrocladia villosa*, when placed upon paper, makes it transparent as if dipped in oil,* and *Desmarestia ligulata* and *herbacea* have the same property.

6. Fucaceæ, *Ag.*

Inarticulate; spores contained in elliptic or spherical conceptacles, sunk in the frond. Impregnation by spermatozoids.

211. We now come to one of the most important tribes of seaweeds, which seem in many respects to deserve the high

* It was in consequence of this property, that I named the genus *Arthrocladia*, *Elaionema*. The name *Arthrocladia* was proposed two or three months previously by M. Duby.

place which systematists have agreed to assign them, combining at once external perfection, with decided sexual distinctions, either in the same or in different individuals. In some cases they attain the stature even of the more gigantic of the seaweeds. They constitute a great portion of the shore-weeds of our seas and estuaries, and in tropical climes form floating beds many miles in extent. While, however, they are so abundant on the European coasts, they are comparatively rare on those of America, the only really common species being *Fucus vesiculosus* and *nodosus*.

212. A large portion are essentially plants of shallow waters, either exposed at every tide, or uncovered only at spring tides. *Fucus canaliculatus* occurs principally about high water-mark and often becomes dry, reviving again and again on immersion. A few *Cystoseiræ* belong to deeper water; but the common *Halidrys* is of similar habits with such species as *Fucus serratus*. The gulf-weed by its floating habit is intermediate between these and more essentially tropical species.

213. The great bank of *Sargassum bacciferum*, extending between 20 and 25° N. lat., in 40 W. long., occupies the same position as it did in the times of the earliest navigators, and between this and the American shores are various detached tracts, influenced as to situation by local currents. The same individual continually produces new branches and leaves, and thus multiplies the species. Such specimens never produce fruit; but whether they receive fresh accessories from plants produced on rocks, is at present uncertain. The fact of these floating masses being barren, is strictly analogous to that of *Macrocystis*, producing fruit only on young attached specimens. In both cases multiplication is so rapid in the floating beds as to render fruit needless; and even the common *Fucus vesiculosus* occurs in the Mediterranean under a peculiar form, consisting entirely of specimens derived from sea-born weed, carried in by the current which sets in towards the Mediterranean from the Atlantic.

214. There is a curious fact, with respect to the geographical distribution of *Cystoseiræ*, as remarked by Dr. Hooker,

that though they abound in New Holland and the West Pacific, they are nearly absent from analogous positions in the longitude of South America, though there is nothing to prevent the fullest interchange between New Zealand and the temperate seas of South America.

215. "Throughout all latitudes the two divisions of FUCACEÆ, *Fucoideæ*, and *Cystoseireæ*, form that prevailing marine vegetation to which the name of sea-weed is commonly applied; and the different genera so far arrange themselves within geographical limits, as to present, with few exceptions, a most harmonious assemblage. Thus in the opposite cold and frigid zones, the waters are inhabited by certain genera of *Fucoideæ*, which are in a great measure representatives of one another, as in the north-east zone *Fucus* proper and *Himanthalia* are represented in analogous southern zones by *D. Urvillæa* and *Sarcophycus*.

"None of these approach the tropics, for the *Fucoideæ* abound towards the poles, and there attain their greatest bulk, diminishing rapidly towards the equator, and ceasing some degrees from the line itself. The representatives of the *Cystoseireæ*, in the higher latitudes of the opposite hemisphere, are equally appropriate with those of *Fucoideæ;* for we have in the north cool zone *Cystoseireæ* and *Halidrys*, represented in the south cool zone by *Blossevillea* and *Scytothalia*, while the immense genus *Sargassum* finds its maximum in lower latitudes, and under the equator itself." Hook. Fl. Ant. *Scytothalia* is found on the icy shores of the Antarctic in the longitude of Cape Horn, though entirely unknown in warmer seas of the same longitude, and supposed to require a high temperature for its development, and, what is curious, under one of the very finest species of the group to which it belongs.

216. *Fucaceæ** differ from all other tribes of Melanosperms in having their fructifying organs disposed on the walls of conceptacles, the exact analogues of the perithecia of *Sphæriaceæ*, as *Xylaria*, immersed in the fronds, or rather in particular

* Consult on the fecundation of *Fucaceæ*, in addition to other memoirs cited from Annales des Sciences Naturelles, those in sér. 2, vol. 19, p. 266; sér. 4, vol. 2, p. 197.

transformed portions of the frond, thicker and more juicy than the rest, called receptacles. The fruit consists of two kinds of bodies; larger cells filled with endochrome, and smaller (antheridia) containing a number of spermatozoids, furnished with two flagelliform appendages. These sometimes grow together in the same plant, or occur on distinct individuals. The endochrome of the larger cells is at first simple, but it subsequently divides* into two, four, or eight distinct spores. It has two distinct coats besides that of the spore cell. The coats are united at the base, and when the spores are ready for dispersion the inner coat bursts through the apex of the outer, dragging with it a portion of this latter in the form of a little peduncle. The immediate covering of the spores at length bursts, and they are set free. Before the rupture of the sacs, the spermatozoids sometimes swarm on the surface, and in this case derange their perfect evolution. When the spores are free, their surface is equally occupied by the spermatozoids, which by their motion roll them over, so as to appear like zoospores. In this state they are entirely destitute of any envelope, as is the case with the spores of *Vaucheria* before impregnation.

217. The real nature of the active granules in *Fucus serratus*, *F. vesiculosus*, and *F. nodosus*, &c., has been fully proved by M. Thuret. Their spores and antheridia were carefully collected from plants out of which they had oozed in a moist atmosphere, and then placed in salt water, and either kept apart or purposely mixed. In the former case, after a few days the spermatozoids collected in swarms, retaining their power of locomotion from one to three days, at the end of which they perished, while the spores continued healthy for eight days, and even made an attempt to germinate, without, however, any division of the endochrome, and then perished. When, however, the cognate spores and antheridia were placed together, the spermatozoids soon swarmed round the spores, retaining their motion as before, from one to three days, and then gradually losing their activity, while the spores themselves began to change their appearance ; the

* In *Himanthalia*, *Halidrys*, &c., it does not divide at all.

walls became more distinctly defined, the endochrome divided into two parts, one of which, in cultivated specimens at least always that which was turned to the light, pushed out a little root-like appendage, the divisions of the endochrome and rootlets increased in number, and finally a young plant was produced with a tuft of threads at its apex like those which are so common on the leaves. The spermatozoids then must really possess the power of impregnation, since their presence is absolutely necessary to the evolution of the spores.

218. But M. Thuret carried his researches further. By mixing the spores and spermatozoids of different species, he

Fig. 59.

a. Antheridia of *Fucus vesiculosus.*

b. Spermatozoid.

c. Spore cases of ditto. By an error of the engraver, their attachment is not correctly represented.

d. One of the eight spores into which the endochrome of the spore case is ultimately resolved. After Thuret. All more or less magnified.

e. Spore-case and antheridia of *D'Urvillæa Harveyi*, magnified. From a drawing by Dr. Hooker.

found that in one case he succeeded in obtaining impregnation. The spores of *Fucus nodosus* and *H. lorea* refused to germinate when treated with the spermatozoids of *F. serratus;* on the contrary, those of *F. vesiculosus*, a species especially prone to run into varieties, germinated freely under the same circumstances. The impregnation then is clearly of a nature altogether similar to what obtains in those reptiles whose eggs are fertilised, when free, by means of spermatozoa diffused in the surrounding water.*

219. A large portion of the *Fucaceæ* are supported in the water by means of bladders formed in their stems or fronds, such as have already appeared in *Macrocystis*, or in special processes, often symmetrically disposed, and giving great beauty to the species, in combination with the variously formed receptacles. The bladders are sometimes solitary; but sometimes, as in *Halidrys*, they form pods, containing a double row of chambers. Besides these appendages, the fronds are often sprinkled with little pores, producing a tuft of colourless filaments proceeding from within. These probably act like the delicate hairs on the roots of many Phænogams, exposing a large surface to the surrounding medium capable of imbibing nutriment, or effecting an interchange between the gases which may exist in the plant and those which may be contained in the water. The pores seem to be analogous to stomates.

220. *Fucaceæ* afford a large portion of the kelp and iodine of commerce, and food to cattle. Like the *Laminariæ*, they supply an abundance of excellent manure. One or two genera also, as *D'Urvillæa* and *Sarcophycus*, are useful in other respects to men.

221. The numerous genera† in this tribe are distinguished

* Capt. Carmichael was, I believe, the first to ascertain the double system of organs in *Fucaceæ* about thirty-five years ago; but, like many of his discoveries, for want of a proper medium of publication during his life, and especially owing to the disastrous state of the book-trade a short time previous to his decease, this also remained in manuscript.

† Decaisne and Thuret have proposed genera for our common *Fucaceæ*, depending on the number of the spores and other points connected with the fruit. Thus *Fucus nodosus*=*Ozothallia, Fucus canaliculatus*=*Pelvetia*.

by the disposition of the bladders and receptacles, and in the more or less distinct evolution of distinct leaf-like organs. While some assume the most elegant foliage, set off by the bunches of receptacles and the elegant vesicles, others present stiff and rugged stems with prickly processes, which bear little resemblance to leaves, or at least to such as have an expanded lamina.

222. *Splachnidium*, a genus almost confined to the southern hemisphere, is in appearance and consistence merely a magnified form of the receptacles of our common seaweeds, being equally gelatinous and difficult in certain states to preserve. The frond and receptacles are altogether confluent. *D'Urvillæa*, one of the most extraordinary of Algæ, is allied to *Himanthalia*, with which it agrees in habit, though so much larger in its dimensions. It has no receptacle distinct from the frond. The structure of the frond is extremely beautiful, which is distinguished by very large and regular cavities, so as to resemble a honeycomb. As in the neighbouring genera, the spores are quadrifid; and it is probable, from Dr. Hooker's observations, that there are antheridia on the same plant. The poorer classes of Western Chili use this plant for food, and the soup made with it is sweet and mucilaginous. The dichotomous fronds, which are two inches or more broad, attain the length of ten feet. *Sarcophycus* is very nearly allied. The only species, *S. potatorum*, so named from pieces of the frond being used to hold water, has been proved by Dr. Hooker to have fruit precisely of the same structure as *D'Urvillæa*. These are succeeded by genera in which there is some little distinction at the base, as *Myriodesma* and *Carpoglossum*, all the species of which belong to the southern hemisphere. We have, however, on our own coasts a seaweed of great singularity from the excessive disproportion between the frond and the receptacle. The frond of *Himanthalia* is a small Pezizæform knob, from a depression in the top of which spring one or two papillæ, which ultimately give rise to a dichotomous thong-like receptacle, two or three feet in length, entirely covered with fruit. The true frond sometimes becomes hollow and swells into a bladder. *H. lorea* extends from

Norway to Spain, and a somewhat doubtful species occurs at New Holland. *Hormoseira* comprehends Algæ in which the frond, which is at first even and filiform, is inflated, so as to produce moniliform chains of vesicles, parts of which are at length rough with the apertures of the conceptacles. It belongs exclusively to the south. *Hormoseira,* like *Fucus, Cystoseira,* and *Halidrys,* with which the English botanist is familiar, and many other genera, is distinguished by the circumstance that the bladders are formed by some swollen portion of the frond; while in *Sargassum* they are distinct organs, performing no other necessary function, though arising from the transformation of what would have been a branch or leaf had it gone through its full course of development.

223. *Cystoseiræ* are abundant on our southern coasts, but they are rare as we advance upwards. Their heathlike fruticose or spinulose habit renders them conspicuous. *Cystoseira ericoides,* especially, is remarkable for the prismatic colours which it exhibits. "It appears," says Dr. Harvey, "clothed with the richest tints of blue and green, more like those phosphorescent gleams that flash from the lower marine animals than any vegetable colours. As each twig waves to and fro in the water, the hues vary, and sometimes, when the light falls partially on a branch, some portions seem covered with sky-blue flowers, while others remain dark. All these beautiful tints perish when the plant is removed from the water." We know little in this country of the other section of *Fucaceæ,* which includes those which have organs distinct from the frond. A few specimens only of *Sargassum* are occasionally drifted to us by the waves. Some of the genera belong exclusively to the southern hemisphere, and *Sargassum,* which contains a multitude of species, is a lover in general of warm seas.

224. It was stated under Rhodosperms, that the effect of a stream of fresh water upon *Chondrus crispus* is to thicken the frond, and to make it less branched. Precisely the contrary effect obtains in *Fucus vesiculosus,* which, in proportion as it is less abundantly and constantly supplied with salt water, becomes thinner and more divided, till it is a complete

Pygmy, without bladders, and with scarcely any midrib. Such is its condition when growing on salt marshes, where it is only occasionally covered, in which, perhaps, it never bears fruit. *Fucus ceranoides* is peculiarly abundant where fresh water enters, but it is not confined to such localities. In proportion as the salt increases, the frond becomes broader, though it still remains thin in comparison with *Fucus vesiculosus*, of which there is a variety with lateral fruit. It is destitute also of bladders; but that is a variable character, for even in large forms of *F. vesiculosus* they are sometimes wanting. *Fucus nodosus*, near high water, is short and bushy; but at low water it is much drawn out, and very different in habit. It has been supposed that *Fucus Mackaii* is only a variety of this, which is not attached, but flourishes amongst loose boulders, gravel, and other similar matter. But the pendulous fruit seems to furnish a good and certain character. *Cystoseira fœniculacea*, again, puts on different forms, under circumstances which are perfectly appreciable. In deep water, especially in summer, it has broad leaves and large bladders, and is *C. discors;* in shallow pools, or late in the year, it is more branched, with narrower leaves, and is *C. abrotanifolia.* In like manner, *Halidrys siliquosa* is bushy and dwarfed near high water, and smaller in every part than when less exposed. *Stilophora rhizodes*, in the deep water of land-locked bays, which are not liable to disturbance, acquires a fistulose stem, divaricate branches, and attenuated branchlets, and is then *S. Lyngbyci;* at least such is Dr. Harvey's opinion, who remarks, moreover, that *Asperoccus Turneri*, when growing with it, is three to four feet long, and proportionally broad, while in shallow pools it seldom exceeds six inches. *Chorda filum* presents strictly analogous varieties under similar circumstances, as does also *Dictyota dichotoma.* We may, therefore, safely assume that the effect of deep water on Melanosperms is to enlarge the plant, and render it more luxuriant, while the contrary condition is produced by shallow pools.

ALLIANCE II.

MYCETALES, *Berk.*

THALLOGENS, deriving nutriment from the substance on which they grow, or from the surrounding medium. Fruit various in external character; spores either naked or contained in utricles (asci), and then called sporidia, often definite, frequently of more than one kind, mostly producing a mucedinous mass of threads or cells (mycelium) from which the plant grows; impregnation at present uncertain.

225. The plants contained in the two great families of which this important alliance is composed, though forming two extremely natural groups, are so closely connected with each other, that, contrary to the usual practice, I have ventured to unite them. The fruit is exactly the same, and if there are supposed spermatozoids amongst Lichens, similar organisms exist equally amongst allied Fungi. The general observations will come more conveniently under the two separate heads, as repetition will be avoided. The motives which suggest their union will also be more clearly understood after reading the details under each family.

a. FUNGALES, *Lindl.*

FUNGI, *Linn.*, *Fr.*, *&c.*—MYCETES, *Spreng.*—HYSTEROPHYTA, *Endl.*

Fungi were defined as hysterophytal or epiphytal mycetals, (more rarely epizoic or inhabitants of inorganic substances,) deriving nourishment by means of a mycelium from the matrix, and never producing from their component threads green bodies resembling chlorophyl.

226. Now, it must be confessed that such a definition is scarcely satisfactory; but in a great natural group, like the cellular Cryptogams, the several members are so closely connected that it is scarcely possible to find strict definite characters. The phrase at least states the important fact that the great body of plants known by the name of Fungi, are distinguished from Algæ by their deriving their nutriment from

the substance on which they grow, and not from the surrounding air or water, like Algæ. It is true, indeed, that a few Algæ, such as *Botrydium*, do probably imbibe something from the soil by means of their rootlets, which can scarcely be mere holdfasts; but still that does not affect the general fact of Algæ being only false parasites. In the same manner, when we examine Fungi more closely, we shall have reason to believe that there are exceptions there also, as to their deriving nutriment from their matrix. I have, for instance, found a *Cyphella* on the hardest gravel stones, where the fine myceli-oid threads, by which it was attached, could not possibly derive any nutriment, except from matters conveyed to it by the air or falling moisture; a species of *Æthalium** was found on iron by Schweinitz, which had been subjected to a red heat a short time before; Mr. Ivor found a *Didymium* on a leaden cistern at Kew, and from the indifference which the Myxogastric Fungi in general show, as regards the objects on which they grow, it is very probable that a large portion of them are dependent entirely on matters contained in the air, and in consequence that many are essentially meteoric. It cannot be supposed that *Spumaria* derives anything from the blades of grass to which it is attached, or which it involves in its progress, after the same fashion that the twigs of trees or annual vegetables are surrounded by the growing pileus of the cortical *Polypori*.

* The account given by Schweinitz is as follows: "A blacksmith at Salem, by no means void of sense or cultivation, had thrown on one side a piece of iron which he had just taken from the fire, being called off to some other business. On his return in the morning, he was astonished to see on this very piece, lying over the water in his smith's trough, a quantity of this fungus. He immediately sent for Schweinitz, without moving anything from its place, who was equally astonished to find a distinct species of *Æthalium*. The mass of Fungi was two feet in length, consisting of a series of many confluent individuals. It had crept from the iron to some adjacent wood; and not, as might be objected, from the wood to the iron. The immense mass had grown in the space of twelve hours." I have myself seen a specimen of this fungus, which Schweinitz calls *Æthalium ferrincola*. It has some resemblance to *Reticularia umbrina*. The spores are precisely the same size, $\frac{1}{4000}$ of an inch, but the structure is rather that of *Æthalium*.

227. We have here, therefore, some first exceptions to the hysterophytal or epiphytal habit of many Fungi. But not only must we make exception for such Fungi as imitate Algæ or Lichens, in deriving nutriment from the surrounding medium ; a further exception must be made in favour of a considerable quantity of species which really live on inorganic matters. Now, it is true of many epigeous species, that, like similarly situated Phænogams, they live on matter derived from the solution of humates or ulmates contained in the soil, and as these result from the decomposition of organic matters, principally or originally derived from the vegetable world, they are really hysterophytal. But, allowing this, it must still be confessed that there are many species which seem to live on mineral matter. There are, for instance, numerous exotic *Polypori*, which grow on volcanic tufa or on exposed soil, in which a very small quantity only of organic matter, if any, can be supposed to be present. *Coprinus radiatus* grows abundantly on plastered walls, either bare or whitewashed, where the minute quantity of size is evidently no element in the question, and we have seen *C. disseminatus* in a similar situation producing most abundant mycelium, and that on stuccoed walls void of all organic matter. Instances also might be brought forward of three or more species of *Peziza*, and those of considerable size, which flourish in such positions; *Chætomium elatum* occupies not unfrequently the same locality as does *Lycogala parietinum*, and the list might easily be increased. Nor in these cases is there any subjacent wood, from which the mycelium might spring, and thus, after penetrating the coat of lime, produce its fruit in the free air. In the cases of *Chætomium* and *Licea*, we have Fungi peculiarly indifferent to the substances on which they grow, and it is possible, therefore, that they may belong, more properly, to the first exceptional case.

228. A third exception to the most salient character of Fungi, is that several species either grow on living animals or on animal substances. *Botrytis Bassiana* is a familiar instance, which produces the disease in silkworms called muscardine.*

* Other caterpillars are frequently as completely mummified. It is

It is not simply that this Fungus is developed on tissues already approximating to decay, but that its spores are capable of communicating the disease by simply falling upon the silkworm, or being artificially placed on its integuments, even without absolute inoculation. Whether *Sporendonema Muscæ* be merely a state of this or not is uncertain, but nothing is more common than to see the Fungus protruding between the abdominal rings in autumn. The flies, which are the subject of attack, soon become heavy in their motions, and attach themselves to any substance which may come in their way by means of their proboscis, and in that situation perish. The Guêpes végétantes of Jamaica are another instance of animals bearing about a Fungus of considerable size, preying upon their tissues, and there is reason to believe that the caterpillars which bear the large *Sphæriæ* in New Zealand and elsewhere, are infested by the mycelium of the Fungus before their death. It is now, however, matter of notoriety, that in the human frame many cutaneous disorders are due to the presence of Fungi. *Tinea lupinosa* is capable of propagation by inoculation with the spores, and there is good reason to believe that even in animals Fungi exercise a very important morbific influence. A hundred memoirs or more could readily be quoted in substantiation of this fact.* It is true, that in many cases the Fungi may be of very common kinds, or under disguised forms, but this is what might readily be supposed, for it is very rarely the case that such peculiar matrices as the human skin, or mucous membrane, should nourish Fungi absolutely peculiar to themselves. It is, in such cases, far more easy to believe that the common *Penicillia* or *Aspergilli*, which are notoriously indifferent about their matrix, provided the proper chemical conditions be satisfied, are the real antagonists. The insect *Sphæriæ* are found in

not uncommon to find them in abundance in garden soil, producing at length a little Isarioid tuft on the surface, and the larvæ affected by species of *Cordyceps*, as in the well-known New Zealand species, are often similarly affected.

* See more especially Robin, Hist. Nat. des Végétaux Parasites, &c., Paris, 1853.

no other habitats, though analogous species exist in less abnormal localities.

229. Having disposed of these exceptional cases, there can be no question that the great mass of Fungi is really either hysterophytal or epiphytal, restricting the latter term to those species which affect living vegetables. Fungi are indeed one of the great instruments which keep up the balance between animal and vegetable life. No sooner does death take possession in any vegetable, than a host of Fungi of various kinds, are ready to work its decomposition. This is at once evident in all softer structures, which are soon reduced to humus by the combined action of putrescence and Fungi; the one, in fact, being frequently the handmaid of the other. The hardest wood, however, yields, though more slowly, to the same agent, and, indeed, far more rapidly than it would do under the action of mere climatic conditions. A stump of one of our largest trees, if once attacked by Fungi, will, in a short time, present a mere mass of touchwood, which is nothing more than woody tissue traversed and disorganized by mycelium. The same stump, if simply left to the action of the weather, might be half a century before it was fairly decayed. The appearance of such a Fungus as *Polyporus squamosus* is the sure harbinger of speedy decay. Nor is the case much mended, supposing vegetation still to exist in the stump; for though the mycelium cannot prey on cells full of vital energy, life is so depressed by the presence and contact of tissues already diseased, that the healthiest soon fall a prey to the spreading mycelium. There are, indeed, hundreds of Fungi of the most varying size, form, and appearance, which more or less speedily accomplish the same end, and there is sometimes a host equally fatal to some individual species.

230. But not only are there numerous species which grow upon vegetable matters already decomposed, or which, by their presence, promote the decomposition of materials already divested of life, but there are very many also which are the express enemies of living tissues; species of which it cannot be said that they are at first propagated on plants, or in tissues already in a low state of vitality, but which induce such

a state by their presence. Such species are, in fact, true epiphytes living at the expense of the plants on which they are developed and flourishing, while they flourish, though tending, by their presence, to exhaust the plant which bears them, and causing the destruction frequently of the parts to which they are attached. The whole tribe of rusts and mildews is a pregnant example. In annual plants, the quality and quantity of the seed are often very materially affected, if it is not altogether destroyed; and even in larger perennial plants, as in the Junipers and Evergreen Beeches for instance, there are parasites which spring every year from the old mycelium, which end in the total destruction of the branches on which they grow. In some instances the plant is deformed by the presence of the parasite, and this deformation involves the organs of fructification; and as the cereals beyond all other plants are subject to such affections, the injury is duly estimated by the cultivator.

231. The only remaining character, which is a negative one, is, I believe, without exception. At least, I am not aware of any, though it is occasionally matter of doubt, whether some particular production be a Fungal or Lichen, in consequence of the absence of gonidia.* In our present state of knowledge therefore, though such absence may not be positively conclusive against a particular production belonging to the Lichens, it is absolute as regards Fungi. Indeed, there is not a single instance amongst the latter, in which a pure vegetable green occurs. Green tints are by no means common, but when present they always approximate to mineral shades. *Agaricus æruginosus*, *Peziza æruginosa*, &c., are familiar examples. The *Russulæ*, which display the greatest variety of colours even in the same species, are never of a pure green, a tint which is characteristic of gonidia.

232. The terms of our definition then being thus explained, we can proceed to some general remarks on this very impor-

* The nearest approach to gonidia occurs in a very curious genus, transmitted to me by my son, from Secunderabad, to which I have given the name of *Emericella*. It will be noticed in a future page. The bodies which resemble gonidia are not, however, green.

tant order of plants, which, from the poisonous qualities, the evanescent nature, and the loathsome mass of putrescence presented in decay by many species, have become a byword amongst the vulgar, and are frequently regarded as fit only to be trodden under foot. However such characters may apply to many, there are numerous species which afford a wholesome and sometimes a delicious article of food, and there are others which vie in duration with their close allies, the Lichens. Indeed, nothing can be more various than the forms which they assume, insomuch that the fleshy mushroom at first sight has little in common with the hard horny *Hysterium*, and yet, perhaps, no branch of the natural world abounds in nicer transitions, while the groups are often so natural as to make it extremely difficult to assign strictly definitive characters. We are, in fact, frequently obliged to have recourse to mere texture, where no essential differences of intrinsic structure can be found.

233. From the very notion of a Fungus, as distinguished from Algæ, it is evident that such a thing as free cells, indefinitely increasing the species, without any ulterior development, cannot exist. In all Fungi there is a portion, consisting either of threads, or more or less closely compacted cells, arising in the first place from the processes put forth by germinating spores, and increased by their division and further development, to which the name of mycelium has been given. This may consist of cottony threads of extreme delicacy, or of closely compacted horny membrane; but still its office is the same, and it may exist in either form without producing fruit, exactly as a tree may remain barren in a soil or climate which is not congenial. In some cases, as in the substance called *Xylostroma giganteum*, it forms sheets as thick and dense as leather, destroying wood of the firmest and most solid tissue, without attempting to produce a pileus; and parallel cases, as in the mycelium of some of the larger *Sphæriæ*, may easily be found amongst the black and ascigerous forms. There can be neither a perfectly free mycelium, nor free organs of reproduction, except in aquatic or aërial species, which are of very rare occurrence. Even if floating, there will be something in

the shape of roots, and the spores will always spring directly from the threads, or be formed within the threads, at the expense of the endochrome. It is very true that the yeast plant may be indefinitely increased by constant pullulation of free floating cells, without a trace of rootlets, and for this reason it has been considered as an Alga. But as it has been proved by myself and Mr. Hoffman,* by following up the development of individual yeast globules in fluid surrounded in a closed cell with a ring of air, that the proper fruit is that of a *Penicillium*, and as this *Penicillium* has, on more than one occasion, been observed to grow on fermenting matter, it is quite clear that yeast is merely an abnormal state of a Fungus, very different in habit, and forced into a peculiar mode of development by its submerged position. I believe equally that *Saprolegnia* and *Achlya* mentioned above (p. 132), with their active zoospores, are mere submerged states of species of *Mucor*. There are, besides, a whole host of mycelia produced in vegetable and mineral infusions referred to Algæ, which are nothing more than submerged confervoid forms of species of *Penicillium* and *Aspergillus*, very commonly of the two most ordinary kinds. In general, however, simple in structure as the lowest may be, and there are many that apparently consist only of a single cell, there is, as said above, a more or less apparent system of threads or cells (mycelium) from which they spring, traversing frequently the tissues of the matrix, and discoverable only by close microscopic investigation ; and even if there be cases where no mycelium exists, a fact of which I very much doubt the reality, or even the possibility, though the mycelioid system may be reduced to an extremely low degree of development, there is usually a definite arrangement of the spores, a point very easily recognised, except in the very rare cases in which, by repeated division, they are apparently indefinite. The fact, indeed, is, that in the greater number of Fungi, the fruit bears a very high proportion, indeed, to the vegetating part or mycelium. But the enormous pileus of the Horse Mushroom does not bear a larger ratio to

* See Article YEAST, in Morton's Cyclopædia of Agriculture.

its mycelium than the bud of a *Rafflesia* to its thallus, if such it may be called. The two cases, in fact, are strictly analogous. Allowing, then, to every Fungus a vegetative system and a fructifying system, we shall first have cases in which the two are confluent; and when once the fructifying system gains a marked ascendancy, we shall have every conceivable variety which can arise from the composition of the fructifying threads, consistent with their main end of producing fruit, and not merely of exposing the largest surface possible to the influence of the surrounding elements, though that end may sometimes be secured concurrently with the other. Though nutriment is undoubtedly derived from the matrix on which the mycelium grows, it is not to be denied that much may be imbibed by the surface of the fructifying mass, which comes in aid of the small portion which could be carried up by the comparatively diminutive mycelium. The mycelium, however, will still convey the elements which are necessary for the peculiar species, the matter derived from the air being the same in all cases alike, whether fluid or gaseous. According to the degree, therefore, in which the cells belonging to the fruit are compacted, we shall have the free or fasciculate cottony threads of moulds, the large and complicated spores of rusts resting at once on the mycelium; the waxy hymenium of *Pezizæ* and *Corticia*, the highly developed pilei of mushrooms, the horny perithecia of *Sphæriæ*, and many other forms, increased moreover by differences in the shape of the component threads or vesicles, and the texture of their cell-walls, and consequent powers of endurance.

234. But there are differences too which depend upon the nature of the fruit. The true fruit of Fungi is formed on two separate plans; in the first the tips or branchlets of certain privileged threads or cells of the fructificative mass swell into bodies, surmounted by little spicules which gradually give rise each to a single cell, whose endochrome is either condensed into a single mass, or becomes compound by the formation of membranous partitions. This mode of fructification is called acrosporous, and obtains amongst the most highly developed Fungi. In such cases the spore ultimately falls off; and in the

16 *

compound spores, either all the endochromes remain combined, or they ultimately separate; but in each case, every endochrome, if perfect, is capable of sending off one or more threads, under the process of germination.

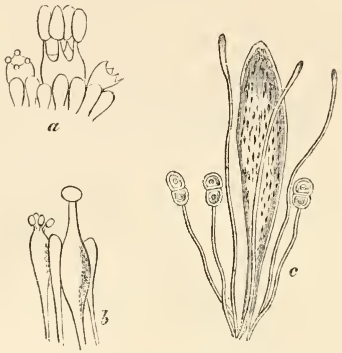

Fig. 60.

a. Sporophores, spicules, and spores of *Agaricus velutinus.*
b. Ditto and urn-shaped process of *A. blandus,* Berk.
c. Ascus and naked spores springing from the same hymenium, in *Tympanis.* All magnified.

235. In the other case, as before, certain privileged threads swell out, forming either bags or tubes, and the protoplasm, without any formation of partitions or dissepiments, is resolved after a time into a definite or indefinite mass of spores, often eight, or multiples or measures of that number. This mode of fructification is called ascigerous; and it frequently happens that in the fruit thus produced dissepiments are formed, as before, thus multiplying the points at which mycelium can be developed. It follows almost as a consequence of this mode of fructification, that the common mycelium of a Fungus may

proceed from the evolution of many spores, and that the fructifying mass proceeding from it may equally arise from many individuals, a fact pointed out many years since by Ehrenberg.* In fact, an Agaric, which is perhaps the highest point which a Fungus can obtain, may be considered theoretically as a multitude of individuals of *Botrytis* compacted together, and bearing fruit at their free extremities. Figures illustrative of this are given by Ehrenberg in his *Mycetogenesis;* and the

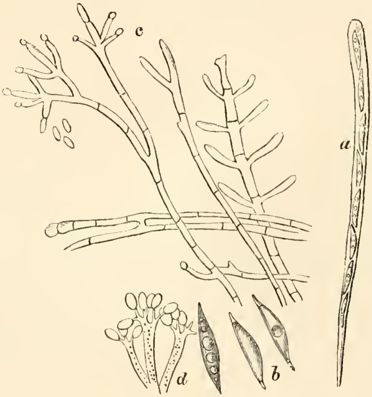

Fig. 61.

a. Ascus of *Sphæria Desmazierii*, Berk. and Broome.
b. Sporidia of ditto.
c. Mycelium of ditto, with conidia.
d. *Botrytis curta*, Berk. All magnified.

Botrytis of the Anemone (Fig. 61, *d*) is an apt case in point, as exhibiting the fructifying tips or sporophores of an Agaric apart from the rest of the plant.

236. These two modes of fructification give rise to two im-

* De Mycetogenesi.

portant series, and afford excellent characters for distinguishing analogous forms, but they are not so strict as might at first sight be supposed, because, in addition to the normal mode of fructification, there is another medium of propagation, by means of cells separated as in the first case, from the tips of filaments or their branchlets. These are what Fries has called conidia, and there are few groups of Fungi in which they have not been observed. In consequence, the same species may in its different stages of growth be referred to perfectly distinct orders: the common *Hypoxylon deustum* may, for instance, be taken for a *Thelephora*, or an *Erysiphe* for an *Oidium* (Fig. 20).

237. But besides these bodies, which are evidently supplemental or analogous to the reproductive buds of *Achimenes* or *Lilium*, there are others, which have at present not been observed to germinate, or only imperfectly, and which there is reason to believe are either spermatozoids or their analogues. The bodies, like the spores themselves, appear under two types, being produced at the tips of certain threads or within vesicles. In the latter case, however, occasionally, as in *Trichothecium roseum*,* it is from the tip of the thread or columella within the vesicle that they are generated. In *Nectria inaurata*, Berk. and Br.,† however, the same hymenium produces ordinary octosporous asci, and others filled with a multitude of far more minute bodies, which are in all probability spermatozoids or their analogues. At present, these bodies have been observed in comparatively few genera, but the subject has not commanded attention till very recently, and is receiving every day fresh light from the researches of M. Tulasne. No better example can be given than that of *Erysiphe*, for we have there the true ascosporous sporangia, the conidia on the threads of the mycelium and the pycnidia, with their spermatoids or spermatozoids, if such they may be called. The connection between the *Oidium* and *Erysiphe*, is proved beyond all doubt, though it does not follow, as a

* Hoffman in Bot. Zeit., vol. 12, p. 249.

† See Gard. Chron., 1854, p. 470.

necessary consequence, that there should be no genuine species of *Oidium*. In the same way it is quite clear that many species of *Sphæropsis*, *Phoma*, and other acrosporous sphæriæform Fungi, are merely states of true *Sphæriæ* and their allies. In some cases the proper fruit of *Diplodia* and *Tympanis* grows on the same hymenium, as observed by myself and Mr. Broome;* but, as before, it is not matter of necessity that there should be no genuine species of such genera. While, therefore, we recognise this diversity of modes of reproduction, the essential weight of the external or internal production of spores will not be affected; and while the general arrangement will comprise equally natural groups, we shall be in a condition to understand exceptional cases more correctly.

238. Very important discoveries have been made very recently by Tulasne, Caspary, and others, respecting the fruit of certain moulds. Many of those species of *Botrytis*, for instance, which were separated by Corda under the name of *Peronospora*, and of which the potato mould and cabbage mould (Fig. 23) are examples, bear also amongst their mycelium large globose bodies, which are evidently a second form of fruit. *Artotrogus*, Mont., is probably one of these bodies. But, more than this, the common *Aspergillus glaucus* has a secondary form of fruit, which is in fact the well-known *Eurotium*, which in its perfect state is ascigerous. The facts which have been ascertained are at present too few to warrant any general deductions. An attempt has been lately made in Hedwigia to show that *Cladosporium herbarum* has spiral spermatozoids, but the matter requires confirmation before it can be admitted as a fact.

239. At present, as far as I am aware, nothing more than mere molecular motion has been observed in the representatives of the spermatozoid granules, except, indeed, the genus *Saprolegnia* be admitted into Fungi. It is probable, indeed, that they are merely representative, and that they are capable of reproducing the species exactly as the zoospores of Algæ.

* Hook. Journ. and Kew Misc., vol. 3, p. 319.

240. Fungi, like Algæ, for the most part exhibit merely different modifications of cellular tissue, but they do not, as at present known, show the tendency which many Algæ do, to produce dotted cells; that is, cells in which the walls are pierced within a little distance of the extreme surface, in order to render the transmission of fluid more easy. There are, however, a few cases in which as undoubted vascular tissue is produced as in any Phænogam; as, for example, in the capillitium of *Trichia* and *Batarrea* (Fig. 5), where the tissue performs the same part as the elaters of *Jungermannia*. It is, however, far from common in the Myxogastres, and is wholly deficient in the closely allied genus *Arcyria*. It is very doubtful whether in either case it performs any office of aëration similar to that which obtains in Phænogams.

241. One of the most curious cases of the formation of analogues of spiral cells is that reported by Bary,* in the case of the transformation of portions of the mycelium of *Aspergillus glaucus* into the sporangia of *Eurotium*. Either two contiguous branchlets, or a portion of the centre of a thread are twisted round so as to form a body shaped like the nucule of a *Chara*, but at first hollow within. The spirals after a time become incorporated, cells are generated from them, the cavity is filled with protoplasm, and ultimately asci are formed filled with spores, which, like those of the mopshaped heads, are capable of germination. I have had no opportunity of examining the matter myself, and therefore simply report the statement of Bary. He does not himself profess to have observed every intermediate stage.

242. The cellular tissue varies in almost every conceivable way, both as regards form and composition. Cells occur perfectly globose, and also extremely elongated and attenuated; and in some instances, as in *Vaucheria* (Fig. 22), not a single dissepiment is formed (Fig. 23) from the first germination of the spore till impregnation, so that the whole plant is a single ramified cell, whose apices fall off and reproduce the species. By a combination of differently formed cells, whose

* Bot. Zeit., v. 12, p. 425.

walls vary much in thickness, masses are formed, of such extreme delicacy as hardly to outlive a slight rush of wind; or so hard as to endure the waste of the exposure of years to the elements. The tips of the threads, again, often anastomose, so as to form a close cellular tissue, in which the passage from dissepimental walls and threads is almost imperceptible, as in many Algæ. In some instances, as in the edible genus *Cyttaria*, the walls of the component cells in certain parts are so thick and gelatinous as to admit of comparison with the thick coated cells of the foliaceous Algæ, In some instances the gelatinous element, as in the *Myxogastri*, is so predominant and in such a state of fluidity as to baffle research. The younger state of most of these bodies is at present almost unknown, and all that has yet been made out of their morphosis, is derived from inspection of specimens, in which the gelatinous condition was in the act of transition to the filamentous and furfuraceous.

243. In the milky Agarics, and in some closely allied *Russulæ*, Corda has detected a system of cells, which may be considered identical with the vessels of the latex in Phænonogams. These cells, however, in point of structure, do not seem to differ from others, though they are ramified. They appear to be free from dissepiments and distinguished only by their form and by the peculiar substance which they contain.

244. Fungi differ no less in size than in texture; some are amongst the most minute productions of the vegetable world, while others are a yard or more across; in almost every case, however, the reproductive bodies are minute, though varying from the twenty-thousandth to the two-hundred-and-fiftieth of an inch in diameter.

245. The localities they affect are as various as their forms. Wherever there is moisture combined with a proper degree of temperature, together with organic matter, Fungi are capable of existence. The spores of the *Penicillium*, which infested the bread some years ago in Paris to such an alarming extent, were capable of sustaining a heat equal to that of boiling water without losing their power of germination, and it is cer-

tain that they can bear many degrees of frost without injury. Some species, at least, are to be found in a growing state whenever the soil is actually free from frost, and many seem to flourish most vigorously at a low temperature. Fungi, however, decrease in frequency as we approach to colder regions, and though common in the tropics, where the air is sufficiently moist, a circumstance on which they depend far more than on the quantity of rain, their maximum is obtained in temperate regions. Sweden, with its various soil, large mixed forests, and warm summer temperature, seems to produce more species than any part of the known world; and next in order, perhaps, are the United States, as far as South Carolina, where they absolutely swarm. A moist autumn after a genial summer, is most conducive to their growth, but cold wet summers seldom are productive. The portion of the Himalayas which lies immediately north of Calcutta, is perhaps almost as prolific in point of individuals as the countries named above, but the number of species on examination proves far less than might at first have been suspected. It is probably not above a fifth of what occurs in Sweden.

246. As regards geographical distribution, we do not observe the same marked distinctions which occur amongst Algæ. A large portion of the species are common to similar latitudes and climatic conditions, and there are few marked distinctions of genera. *Agaricus* and *Polyporus* occur in all parts of the world, and the same may be said of the different groups into which they have been broken up with few exceptions. A few genera, such as *Secotium*, *Montagnites*, *Gyrophragmium*, occur only in the warmer regions, having their northern limit in the north of Africa, or the coast of the Mediterranean; but it can scarcely be said of any that it is absolutely confined to any one of the main divisions of the world. *Mitremyces*, which was once supposed to belong only to the United States, has now appeared in Australia, Java, and the Himalayas; *Podaxon* occurs in Carolina, Africa, the Cape de Verds, and India; *Trichoscytale paradoxa*, first found in Java, has now been found in Ceylon, New Zealand, the Sikkim Himalayas, and Carolina; *Aseröe* belongs to New Zealand and Ceylon, as

well as Australia, and there is, at least, a closely allied form in India. Of the larger genera, such as *Agaricus* and *Polyporus*, some species, as for instance the common mushroom and *P. lucidus*, occur in almost every part of the world; and in hotter climates the Agarics are mostly identical with species of more temperate climes. Of *Polypori* certain species, as *P. sanguineus* and *xanthopus*, are at home wherever the climate is tropical or sub-tropical; and the more the species are examined, the more widely do we find that they extend. *Polyporus* is, however, far more the genus of warmer countries than Agaricus, and accordingly we find species which we should in vain search for in temperate regions, extending in sub-tropical districts from Carolina to the Philippines. In the Sikkim and neighbouring Himalayas, which abound in Fungi, we have species of every different climate at different heights. We have below, *Pol. sanguineus* and *xanthopus;* higher up, we have the species of Ceylon and Java; we have then the species of southern Europe, and finally the more northern species; or, if we have not the identical species, we have others so nearly allied that it is matter of difficulty to distinguish them. One species occurred as high as eighteen thousand feet, while others flourished in the warm valleys at a comparatively low height above the level of the sea. The Hymenomycetous fungi were, however, far the most abundant, and the Sphærias were barely represented.

247. Fungi occur in localities as various as the forms which they assume; the sandy desert, the open field, the close wood, the bleak mountain, provided there be sufficient moisture, have all their proper species, and those which are parasitic are almost as numerous as the plants which they affect; but not only do they cover the surface of the earth in countless myriads, but there are numerous species which are distinctly subterranean in their habits. The truffles comprise a large number of species, included in numerous genera differing extremely in structure. They occur in various climates, but are confined almost entirely to calcareous districts. The species are very generally diffused, the same kind occurring in central America, Italy, and Sweden. They prefer the warmer temperate regions;

and, while they are rare in Sweden, they increase gradually in number as we advance from England to France and Italy, attaining their maximum probably about Turin. A large quantity of truffles, placed in my hands by Professor Fries, from the Ukrain, proved generally identical with the species of Western Europe. The common moulds are altogether ubiquitous; *Eurotium* is as destructive in the southern as the northern hemisphere, and smut and mildew are alike injurious wherever cereals are cultivated. Little is known of tropical moulds. The curious forms figured rather roughly by Martius have been observed by no one else, and at present are involved in some obscurity from want of information as to their intimate structure.

248. But few undoubted instances of Fungi occur in a fossil state. Dr. Brown, however, has informed me that he has seen mycelium in the cells of fossil wood; and the amber of the tertiary formation* contains *Penicillium* and another genus in a state of such perfection as to make it almost certain that other Fungi were not wanting in those periods of the world, though in general they may not have been able to resist decomposition. A few doubtful productions are assigned to Fungi in lists of fossil plants, but mere external form without opportunity of examining structure is too fallacious to command much confidence. *Polyporus fomentarius* is preserved admirably in the fens of Cambridgeshire, but not according with British forms of the present day. In the Kew Museum, a specimen may be seen side by side with one from Sikkim, the accordance of the two being quite perfect.†

249. In our own country, with the exception of some three or four species, Fungi enter but little into our markets, though the consumption of some of these is very considerable. *Agaricus campestris* and *arvensis* are the source of the greater portion of the really wholesome and fine-flavoured katsup; but thousands of bottles are made every year without

* Ann. of Nat. Hist., n. s., vol. 2, p. 369, tab. 11, 12. I am not certain that the third genus, referred to *Streptothrix*, is properly organic.

† Journ. of Linn. Soc., vol. 1, p. 52.

any discriminate selection of species. As, however, no fatal accidents are ever heard of from the use of katsup, it is probable that the most poisonous species are rejected, and that the principal evil is merely one of adulteration, and the loss of the fine flavour of the real article ; or else the poison may be modified by the culinary process which it undergoes, and the admixture of salt and spices. Truffles are found only at the tables of the rich, for they always bear a high price, though, if there were any great demand for them, the markets might be easily supplied ; for they are far more common in calcareous districts than is generally supposed. Our indigenous species are either small, or if large have a flavour far inferior to the common species of the Paris markets. They have, however, a very delicate aroma, and if dressed by simple roasting are by no means a despicable article of food. The most delicate of all our Fungi, *Agaricus Oreades*, is comparatively neglected and seldom comes into our markets ; and there are some fifty or sixty other species, which afford wholesome food, which are passed by or neglected from ignorance of their qualities. Accidents, however, so frequently happen from the use of improper species, that people are afraid of using the most innocent ; and, unhappily, there is evidence that species accounted the most wholesome, even *A. campestris*, has sometimes proved destructive. It is, indeed, excluded from Italian markets, as most pernicious.* Now, as Fungi form a very important part of the food of many European districts, and are largely preserved for winter use, and that without much discrimination, the unwholesomeness of these productions in our own country may possibly depend upon some peculiarity of constitution, for there is no evidence to show that particular species abound more in pernicious alkalies in one country than in another. In France the uncertainty of Fungi is considered so great, that no Agaric is admitted into the Paris market except *Agaricus campestris*, and I believe exclusively those which are cultivated. They are, however, consumed extensively in many parts of France, to the great

* On this and many interesting matters, Dr. Badham's work on Esculent Fungi should be consulted. The root of *Tetragonolobus siliquosus* smells like fine truffles.

comfort of the peasantry. The mushroom, as said above, occurs in all countries, though differing considerably in size and quality. In Australia there is a variety or allied species which excels the common mushroom in quality, as highly as the finest modern varieties of pease do the old early frame. Spawn of this has been communicated to me, but it was tried in vain. In New Zealand the gelatinous volva of *Ileodictyon* affords an execrable article of food, which would indeed be used nowhere except under great scarcity of better sustenance.

250. *Mylitta Australis*, or the native bread of the Australians, is a better article, and when dry in some conditions looks like hard compacted lumps of sago. *Cyttaria* is quite the staple of the Fuegians during many months of the year, being produced in great abundance on the living twigs of the evergreen beech. It may be proper, in conclusion, to mention that the *Pachyma Cocos* or *Tuckahoo* of the Americans is not a true fungus. It is evidently some state of the roots of some Phænogam, in which everything is replaced by pectic acid. It affords in consequence an excellent article of food, and may be used like isinglass to make jelly, resembling in fact the principle of currants and other fruit, to which their property of forming a jelly when boiled is due.

251. Many fungi are possessed of deleterious constituents which enter probably into the composition of all, though in the innocent species in so small a proportion as to make them harmless. Fatal accidents are by no means uncommon. The best account perhaps of such an accident is that given by Lenz, an excellent writer on esculent and deleterious Fungi, who describes the symptoms which he himself underwent from partaking inadvertently of *Boletus Satanas*. In a case which happened at Cambridge some years ago, the principal species was *Ag. personatus*, a species commonly sold in Covent Garden Market under the name Blewits, and similar instances have occurred with species reported wholesome. Dr. Badham has reported a case which did not end fatally from eating *Agaricus euosmus* by mistake for *A. ostreatus*. Some species are so extremely tough when cooked, that without any especial poisonous properties, their own indigestible qualities are quite

sufficient to account for accident. A curious case is reported in the Gardener's Chronicle, which seems to show that an extremely minute quantity may sometimes induce grave symptoms. Ergot of Rye, which is a well-known remedy in cases where active contraction of the muscles of the uterus is requisite, is no less notorious for the fatal gangrene which it produces when forming a immense proportion in rye used for flour, though the children in some parts of the north of Europe eat with impunity immense quantities of it under the name of St. John's Bread. Some species of mould, when attacking food, are scarcely less injurious, though whether the disease is due to the mould itself, or to decomposition of the matrix on which the mould is developed, has not been clearly ascertained.

252. A few species are used as medicine. *Polyporus officinalis* was long a favourite drug, but it is now out of repute. *Exidia Auricula Judæ* owed its reputation in throat cases, probably, to the fancied resemblance of its hymenial surface to the fauces. The beneficial properties of Ergot have already been mentioned. The fumes of the large Puffball, *Lycoperdon giganteum,* have properties similar to those of chloroform, and have been used to stupify bees, and even in surgical operations. A species of *Polyporus* growing upon the birch, and probably a state of *P. igniarius* or *fomentarius*, or possibly *P. nigricans,* without specimens it is uncertain which, is used when dried and pounded as an ingredient in snuff, by the Ostyacks on the Obi. *Agaricus muscarius,* when dry, is a well-known promoter of intoxication, and constantly used for that purpose by Kamschatdales.* A decoction of it is used for the destruction of flies and other insects. Dr. Badham has reported to me a case, in which some specimens of *A. muscarius,* sent for that purpose to a friend, were accidentally eaten, but, happily, a small portion only was consumed, as they did not prove palatable, and the only conse-

* It is curious that it communicates its narcotic qualities to the urine off the persons who drink it, a circumstance of which the barbarous people avail themselves to prolong their disgusting orgies.

quence was a temporary intoxication, similar to that experienced by persons unaccustomed to the use of tobacco. Yeast is an approved remedy for certain ulcers, and has been used internally. It is scarcely necessary to mention that one of the insect *Sphæriæ* is a favourite medicine of the Chinese. The mode of using it is singular: a bundle of the Fungi, together with the caterpillar attached to them, is placed in the stomach of a duck, which is consumed, when roasted, by the patient. Its virtues are, in all probability, fabulous. The Aphrodisiac qualities of Truffles are equally unfounded, depending merely on fancied analogies, or on notions as to their mode of origin, which it is unnecessary to reproduce here. Some species of *Elaphomyces* are, however, still sold by our herbalists. *Lysurus Mokusin* is used by the Chinese as a remedy in gangrenous ulcers, and it is also eaten, but it is probably as wretched an article of food as *Ileodictyon*.

253. A few species of Fungi are capable of artificial cultivation, and it is probable that were it wished a larger number of species might be constantly propagated. The common bunt is propagated with certainty, by simply rubbing the grains of wheat with the spores; and the rust of the rose (*Coleosporium pingue*, Lév.) may be communicated to trees hitherto unaffected, by watering the ground with a decoction of infected leaves. A few parasitic species, as *Labrella Ptarmicæ*, *Ustilago hypodytes*, *Polycystis Violæ*, &c., may be preserved in the garden for some years, by simply introducing infested plants. The grains of Ergot, if sown and kept in earth slightly moistened, vegetate in a few months, and produce a curious *Cordyceps*, as was first shown by Tulasne, and verified separately by myself and Mr. Broome.

254. The Fungus, however, which has received most attention, and whose cultivation, when carefully conducted, is certain and profitable, is *Agaricus campestris*, or rather a peculiar variety, which is comparatively rare in a wild state. The best way is to prepare the bed with spawn, either taken immediately from the fields, or propagated artificially in the garden; but if certain materials enter into the compost, including the droppings of horses, and the parings of their hoofs, the pro-

duction of mushroom is tolerably sure. Attempts have been made to cultivate the common truffle, but at present with little success. Noé's experiment of watering the ground in woods with a decoction of truffles was successful, and *Boletus edulis* has been raised in the same way; but this is rather promoting their natural production, than strict cultivation. Efforts in this country have, at present, been fruitless, though spawn at least has been produced. The attempts of Bornholz and others may be mentioned, but they do not rest on sufficient authority to make them worth quoting. In Naples, a species of *Agaric* is raised upon the spent marc of Coffee, and a favourite *Polyporus* (*P. corylinus*, Mauri) is grown simply by toasting the stumps of cob-nut trees over straw, and submitting them to a proper degree of moisture in a dark cellar. The Fungus stone (*Pietra Funghaia*) is constantly used in Italy, for the propagation of *P. tuberaster*; and I have seen specimens grown in England, in the nursery of Lee and Kennedy. The Fungus stone is, however, nothing more than a ball of earth matted together by mycelium, which readily fructifies under proper conditions of temperature and moisture.

255. *Polyporus fomentarius,* which is in great demand for Amadou, has been artificially produced in Germany, but not by direct propagation. Finally, *Botrytis Bassiana*, and several epizoic Fungi, are readily propagated by inoculation, while many species of moulds are capable of cultivation in the house, by simply sowing their seed on rice paste, or any other convenient matter, and several of the epiphyllous species, as *Erysiphe*, in their Oidioid condition, are equally capable of propagation by merely scattering their spores on the leaves on which it is desired they should grow. Indeed, many of the moulds will vegetate on any moist surface, or in a drop of water placed in such conditions as will prevent evaporation.

256. Fungi are amongst the bodies which some naturalists consider capable of spontaneous generation. There is, however, no stronger ground in their case than in Algæ. Their sudden and unexpected appearance, their frequently inter-

cellular origin, their powers of enduring extreme temperatures without destruction, &c., are amongst the causes which make certain minds unwilling to admit their propagation after the fashion of other vegetables; or, at least, if they allow that when once produced they are capable of propagating their species, they do not consider it impossible that, like chemical substances, they may arise from a certain concurrence of fitting elements. The existence, however, of a vital principle in these bodies places them under very different circumstances from chemical compounds, and, till we have some undoubted fact in proof that organisms possessing life can spring from inorganic or dead matter, it seems premature to enter into such speculations. There are, indeed, a few difficulties, but these are not such as to require so extreme a solution. That Fungi should spring up everywhere, under fitting conditions, is readily explained by the enormous quantity of fruit which they produce. The dunghill *Peziza*, sending its sporidia from its hymenium in a steamlike cloud, may convince us of the powers of transmission which these particles possess, and a multitude of equally cogent examples might be adduced. A single *Lycoperdon giganteum* alone produces myriads of seeds. Multitudes of spores find at once a proper nidus, and throw out their mycelium, which, in some cases, may exist for years without producing fruit, and in other instances is essentially perennial, yielding an annual crop for almost an indefinite period; as essentially perennial, at least, as many an herbaceous plant, which is propagated indefinitely by means of new roots or bulbs, while the older ones gradually perish. Other spores are wafted about in the air, where they may remain for a greater or less period, till, obeying the natural laws of gravity, they descend in some distant regions. The trade winds, for instance, carry spores of Fungi mixed with their dust, which must have travelled thousands of miles before they are deposited. There is little difficulty, therefore, as regards the ubiquity and unexpected appearance of many species, or the certainty in the case of common kinds of *Aspergillus*, *Cladosporium*, and *Penicillium*, of their appearance, where particular bodies are exposed to the air, and subject to decomposition. Moulds will not appear on substances placed out of the possibility of communication with the external air, or where the spores are obliged to traverse sulphuric acid, or any other corrosive matter, before they can alight upon the substance.

257. As regards their propagation within closed cells or cavities, there is no doubt considerable difficulty. In the potato disease, we have seen *Botrytis infestans* make its appearance in a few hours on the surface of a cut tuber; but, at the same time, microscopic examination has shown the mycelium of the Fungus traversing the cells. But this is far less astonishing than that the same species should grow and fructify in the cavities of the fruit of the Tomato, when there is no apparent lesion of the walls. It is quite certain, from the propagation of bunt in wheat, that the mycelium, or some subtle form of it, must have the power of penetrating to the remotest parts, and of retaining life in those uninjured for some months, till the tissue of the seed is sufficiently advanced for its full development. The occurrence of *Trichothecium roseum*, within the cavity of ripe nuts, is perfectly analogous, but, perhaps, some subtle aperture may let in the spores or spermatia,* though it may be too small to escape our notice. The propagation of moulds within closed eggs appears to present no greater difficulty. It is very possible that a spore might be attached to the egg before the deposition of the calcareous coat, or, as in the case of the nut, there may be an accidental pore in the shell, too small to be detected. The marvellously narrow cracks in drain tiles, through which roots will penetrate, and when they have once penetrated the enormous extent to which they are often multiplied, may make us less ready to see anything beyond our powers of conception, in the occurrence of moulds in such localities, without calling in spontaneous generation to the solution of the difficulty. Fries has remarked, that in *Rhytisma acerinum*, the sporidia

* The spermatia of this species which, according to Hoffmann, germinate, though, as far as he has seen, abortively, are extremely small, when compared with the true fruit. Bot. Zeit., vol. xii., tab. 8, fig. 2.

are sent off in a vapory cloud just at the very time that the young leaves of the maples are expanding, and numerous difficulties of epiphytous Fungi may be satisfied by similar phenomena. The facts adduced by Dutrochet, that alkaline and acid substances produce different moulds, are simply explicable by the same principle on which certain plants are peculiar to salt marshes. Many other instances occur of the development of moulds in closed cavities, into which it was scarcely possible for spores to penetrate from without. The strongest case I have met with is the development of a yellow mould within the cerebral cavity of Golden Pheasants, which soon proved fatal. Enough has been brought forward to make at once the difficulties and probable solution of the question apparent. If it be once allowed that matter may traverse closed tissues derived from spores capable of reproducing a species, the greater part of the difficulty ceases.

258. The productions found in anomalous situations, are very often those which have the widest range, and are the most abundant in individuals, and when it is remembered how much more capability there is in many Cryptogams than in Phænogams, of resisting extremes of temperature, we shall be ready, provided our minds be free from prejudice, to ascribe apparent mysteries to natural causes.* One of the most striking cases, perhaps, is the development of moulds from the globules of milk. Without laying too much stress on the difficulty of following up the development of a single globule amongst a multitude, there can be no reason why spores of *Penicillium*, or at least particles capable of reproducing it, should not be present in the milk as well as the *Oidium* in diabetic urine. And though the true spores are of considerable size, it is more than probable that many moulds, as, for instance, such as grow on paste, decaying meat, vegetables, &c.,

* Those who wish to see the statements of a recent advocate of spontaneous generation and its cognate theories, may consult De Gros' memoir, Ann. d. Sc. Nat. 3 sér., v. 17, p. 193. At the commencement of his memoir, he eliminates several productions which have no claim to be considered as either animal or autonomous.

assume on their first development a form very different from that of the full-grown plants. Before the common species of *Penicillium* and *Aspergillus*, little gelatinous specks of various colours frequently appear, which consist of a multitude of granules, too small to admit of accurate measurement, which, in all probability, are a condition of those species.

259. Fungi are unfortunately injurious to man, not only from their deleterious qualities, but from the direct influence which they exert on many members of the vegetable world, and especially on those which furnish a great portion of his food. Every kind of corn has its own peculiar parasites, which either prey upon the grain directly or impair its quality, and there are some species which are to a great degree common to all. Corn, however, is not the only agricultural produce which suffers; potato crops have for years been ravaged by *Botrytis infestans*, which destroys the leaves and haulm, and finally infests the tuber, at last reducing it to a mass of putrescence. The *Oidium*, or rather the *Erysiphe*, of the vine, has ruined the vine-growers in almost every country where it is an object of cultivation. The year 1854, from the same cause, proved in many districts most disastrous to the hop-growers, except where precautions had been taken to dress the crops with sulphur, which, when applied sufficiently early, appears a specific for that and allied species of mildew. Many other minor instances of loss might be enumerated, due to the same cause. It has also been conjectured, that decay in fruit arises from the attack of Fungi, but this appears to be a mistake, except as a secondary cause. There is no doubt that decay is much accelerated by the presence of Fungi, but not till some previous lesion has existed. If, for instance, a portion of the tissue of a fruit be exposed to the air, the vitality of the divided cells is impaired, the albuminous matter set free acts as a ferment, in consequence of which neighbouring cells are involved, Fungi are established on the decomposing matter, the mycelium of which penetrates into the succulent mass, at whose expense it feeds; those threads which have gone through their course decay, and in their turn act on the cell-walls

with which they are in contact, and thus in a few hours the whole mass is involved in ruin.

260. But Fungi are no less destructive to all kinds of wooden fabrics. Our houses and ships are equally the victims of certain species, which live at the expense of the raw matter contained in the woody tissue. *Polyporus destructor*, *Merulius lacrymans*, and others, soon establish themselves wherever there is ill-seasoned wood or a close atmosphere, in some cases destroying everything before them in a few years, and sometimes in an incredibly small space of time. *Merulius lacrymans* sometimes even extends from the woodwork to the walls themselves, and by penetrating their interstices involves them in destruction no less than the wood itself. Wood which was perfectly untainted when first placed in the structure is soon attacked, but the evil is often pre-existent. Many of our timber trees are deeply tainted before they are felled; and oak, where raised from old stools, and not from acorns, is extremely subject to be impaired by the mycelium of *Dædalea quercina*. Hothouses, and similar fabrics, made of such materials, soon show indubitable signs of the evil, which in a few years goes through its work of destruction. In all such cases, a free circulation of air is indispensable ; but besides this, timber felled in winter and free from raw sap, is far less subject than when spring-felled, though some authorities are against such view. In every case, if there is fear of dry-rot, the timber should be steeped in a solution of corrosive sublimate, sulphate of copper, or some other mineral substance, inimical to the growth of Fungi. The large pileate Fungi do not always appear in the most aggravated cases of dry-rot. In some of the worst there are merely imperfect mycelia, under the form of *Sporotrichum ;* but these have as destructive powers, penetrate as deeply into the wood, and attract moisture from the air, as effectually as the most perfectly developed species. The wonderful power of penetration possessed by mycelium, may be easily seen in any dark-coloured Fungus, by making thin vertical sections through the wood. Not only do the threads penetrate between the cells, but into their cavities themselves, at length completely blocking up the aperture, after traversing

them in every direction. If the green oak, which is used at Tunbridge for ornamental purposes, and which owes its tint to the mycelium of *Peziza æruginosa*, be examined, the coloured threads will be found in every possible position. A striking instance of a similar nature, where a little *Graphium* is the parasite, is represented in the Botanische Zeitung;* and instances are given by myself and Mr. Broome, in the Annals of Nat. Hist., and in a paper on wood from the Arctic Regions in the London Journal of Botany. Very recently, in a piece of drift-wood from Wellington Channel, presented to me by Captain Inglefield, I have detected a similar fact amongst Lichens, which is the more valuable, as it seems to indicate that in an early stage of growth they may sometimes derive nutriment from their matrix.

261. In speaking of the effects of Fungi, in the production of disease, it may not be amiss to add a few words on the supposed capability of their spores producing fevers and allied disorders in man. It is evident that mere surmises as to the possibility are not admissible as proofs, nor any estimates, however large and veracious they may be, respecting the inexhaustible supplies of spores ready to enter with the air into the cavity of the lungs, or to be swallowed with food. Nor can the supposed prevalence of Fungi in stations subject to miasma, be of much greater weight. The remarks of Mitchell and Cowdell,† though men of considerable acquirements, rest merely on theory, and not on actual observation; nor do I know a single fact, the legitimate inference of which is that they can produce fever. The influenza of 1837 was supposed, by several scientific men in France, to have this origin; and no mean abilities were called forth in support of a similar notion, when this country was visited by cholera, in 1849. The curious point was, that bodies were really found in the dejections of cholera patients, the nature of which has not yet been determined. Like the spores of bunt, and, perhaps, some other Fungi, they were undoubtedly consumed with their

* 1847, tab. 4.

† Mitchell, on the Cryptogamous Origin of Fevers, Philad. 1849. Fungous Origin of Cholera, Cowdell, 1848.

food, and there is some reason to believe that they were the pollen grains of some common Cichoraceous plant.* Nothing, however, was ever proved beyond their existence, which, perhaps, did not receive all the attention it deserved, partly in consequence of their being erroneously supposed to be the spores of bunt, and partly because fragments of spiral vessels, and other matters from the common aromatic confection, had been mistaken for Fungi.

262. In connection with this subject it may not be out of place to call attention to the rains of blood, or ink, or sulphur, as they are called, which at various times have alarmed the sensibilities of ignorant or superstitious people. Ehrenberg has with great patience collected, in his treatise on the dust of the trade-winds, records of the most prominent instances. Some, it is known, are due to soot; others, to pollen of conifers or willows; others, to the production of Fungi. Bloodspots are sometimes produced by a species of *Epicoccum;* but the most extraordinary instances are those presented by a production which has been referred to Algæ, and the animal kingdom under the respective names of *Palmella prodigiosa* and *Monas prodigiosa.* My own opinion is that it is a state of some mould, analogous to the gelatinous spots of various colours which appear on meat or paste when in a state of incipient decomposition. It increases with immense rapidity, and is easily propagated; a very singular circumstance being, that from particular spots multitudes of lesser spots extend in a straight line, as if blood had been spirted out from a wounded artery. Mr. Stephens, in an article in the Annals of Natural History, N. S., vol. 12, p. 409, has apparently described some second form of this species, and it is either capable of great change of colour, as specks of yellow, pink, white, and even blue accompany it, or other analogous forms of moulds or allied species occur on the same matrix. The colour is peculiarly vivid, and is capable of communicating a brilliant and permanent dye to many manufactured articles. In the hot days of July, 1853, provisions

* Dr. Ransom thinks they may be the ova of *Ascaris lumbricoides.* See Med. Times, June 14, 1856.

which were cooked in the evening were in some cases the next morning covered with this production. The only instance of similarly rapid development is that of yeast globules, and it is there probably that we must look for the true solution of the question as to its real nature. Unfortunately, experiments on the evolution of Fungi from single spores, require nice manipulation and complete leisure. A few hours' avocation is sometimes fatal to such observations.

263. It has been asserted that powerful odours are inimical to the propagation of Fungi, and the freedom of Russian leather from parasitic moulds has been quoted as a confirmation of the notion. I fear, however, that it is not well founded, except where the odour may be acccompanied by gaseous matter inimical to vegetation; and as regards Russian leather, I can myself answer from my own experience that it is no complete preservative in a damp atmosphere.

264. One great peculiarity of Fungi is, that their relations to the atmosphere are entirely different from Phænogams. They do not help to keep up the balance between animal and vegetable life, so far as the atmosphere is concerned; for, like animals, they exhale carbonic acid and absorb oxygen, and it is to this cause, probably, that the absence of vegetable green in their cells is due. In some cases they are capable of generating considerable proper heat. Dutrochet found that the highest temperature generated by any vegetable, with the exception of *Arum*, was by *Boletus æneus*.

265. Some Fungi are remarkable for their luminous appearance at night, which is often so intense as to yield light enough to read by. This luminosity has been observed in various parts of the world; and where the species has been fully developed, it has been generally a species of *Agaricus* which has yielded the phenomena. *Agaricus olearius* of the south of Europe is one of the best known, but other species have been observed, as *Ag. Gardneri*, Berk., in Brazil; *Ag. lampas*, and some others, in Australia; in Amboyna, by Rumpf., &c. Mr. Babington has observed imperfect mycelia extremely luminous near Cambridge; and Dr. Hooker speaks of the phenomenon as common in Sikkim, though he was never able to

detect the species to which it was due. Tulasne, who has specially examined the luminosity of the Agaric of the olive, has observed dead leaves in the south of France to be endowed with the same property, without, however, being able to detect the cause. Fabre, in a paper just published in Ann. d. Sc. Nat., ascribes it to a temporary increase of oxydation.

266. Beautiful, however, as the effect may be in these instances, it is far excelled by the phosphorescent appearance presented by *Rhizomorphæ* in mines, the splendour of which is described by Humboldt in the most glowing colours. Such *Rhizomorphæ* are, I believe, always mere subterranean forms of common Fungi, as is the case with *R. subcorticalis*. Decandolle long since explained their real nature; but it is very curious, if this be the case, that our common *Polypori* and *Xylaria*, which give rise notoriously to such productions, are not themselves luminous when perfectly developed. One or two properties of Fungi remain still to be noticed. When wounded they are said to heal like the flesh of animals. Though Phænogams in general are incapable of growth where tannin is present, not only several Fungi, as *Agaricus cepæstipes*, and *volvaceus*, delight in what is called spent tan, but which still retains some of its original principle; but a species of Fungus, or rather the mycelium of some unknown species, is developed in wood constantly soaked with a strong solution of tan. Some species of the genus *Boletus* exhibit a very singular change of colour, from white or yellow to a more or less vivid blue. Archdeacon Robinson has examined this phenomenon attentively in different gases, and has arrived at the conclusion that the change depends on an alteration of molecular arrangement.

267. Before entering upon the different forms presented by perfect Fungi, it may be well to say a few words respecting the multitudinous false species and genera which appear in systematic works, in consequence of infantile or abnormal states being considered as perfect. No Fungus, however curious its external appearance may be, should be regarded as of generic value unless fructification be present. This principle alone will dispose of a multitude of supposed species; but, inasmuch

as conidia often make their appearance on such productions, some cases will arise in which mature deliberation will be requisite to arrive at a just conclusion. If these considerations be not kept in view, we shall have the mycelium of Agarics described as *Himantia,* that of *Polypori* as *Rhizomorpha* and *Sporotrichum,* that of *Sphæria* as *Stereum* or *Botrytis,* and so for many similar cases.

268. The early stages of the minute puffballs are so extremely different from the full-grown plant, in consequence of their gelatinous texture, creeping habit, and anastomosing veins, that they have often been described under distinct generic names; and yet a single day's observation might have taught the identity of the two states, however discordant they may be at first sight, because the one distinctly passes into the other, and that within a few hours. There is far more difficulty where a plant is arrested in its growth at a certain stage, having previously undergone important modifications, so as to disguise its real nature. If, for instance, the numerous species assigned to *Sclerotium,* and one or two other neighbouring genera, be observed only during the season which gave them birth, there are few instances in which their real nature is capable of detection. In general they are compact masses of cellular tissue, which have arisen from the metamorphosis of an originally floccose mycelium. This is occasionally very evident, as in the *Sclerotia* of pears and apples, where the mycelium in some cases assumes the form of a *Sporotrichum,* in others the tissues become more compact in the centre of the floccose mass, while in others the mass is of less density, its free tips fructify, and, instead of a *Sclerotium,* we have a state of *Penicillium* which is known by the generic name of *Coremium.* Precisely the same process takes place with several other moulds, but they are not always readily traced. This, however, may be effected by causing a small portion to grow under circumstances which force it to fructify, as was done by myself and Mr. Hoffman, in the granular *Sclerotium* of onions, which gave rise to a minute *Mucor.** Other species, resem-

* Journ. of Lond. Hort. Soc., vol. 3, p. 91.

bling these precisely in outward appearance, are a condensed form of the mycelium of the higher Fungi. The *Sclerotium* of *Peziza tuberosa*, if examined in winter, would suggest no affinity whatever to the species, and the same may be said of such supposed species as *Sclerotium cornutum*, *fungorum*, and *lacunosum*, which are mere states of *Agaricus tuberosus*, *cirrhatus*, and *racemosus*; while *Sclerotium scutellatum* and *complanatum* are conditions of *Pistillariæ*. Whether true species of *Sclerotium* exist at all, is matter of great uncertainty, and even should such species as *S. scutellatum* be found with spores, we should have no right to consider them as more than conidia. If produced at all they would have a very different affinity from that which has in general been assigned to them.

269. The two modes of fructification in Fungi have already been described, and they give rise to two distinct series, one distinguished by producing naked spores, which may be either simple or compound, the other sporidia inclosed in a distinct sac. In some rare cases they are reduced to one; and then, if the external sac is fitted closely to the sporidium, it can scarcely be distinguished from a true spore. We shall give the latter first, which is confluent with Lichens, and the other next in order, as leading to the highest degree of development of which Fungi are capable. There is an advantage in this arrangement, that the anomalous group of the true *Mucors* is placed in close connection with the naked seeded moulds with which they are evidently in close alliance.

The two principal divisions therefore will be—

I. SPORIDIIFERI.

II. SPORIFERI.

270. Till the latter end of the last century, though many Fungi had been described, little had been done in a systematic point of view. A few genera had been established, but many of these were as full of anomalies as the *Fucus*, *Conferva*, and *Ulva* of Algæ. Persoon was the first to exhibit something like order, but it was left to Fries to explain the mutual affinities of the multitudinous forms of which Fungi are composed. This was effected, however, more by natural tact and reflection than by a minute microscopic study. Much, therefore, was

left for his successors; and it is to Tulasne and his brother that we are especially indebted for the elucidation of many difficulties, and the brilliant discovery of numberless new facts. Some of their views had indeed already been anticipated by Fries, though at the time they were first set forth the microscope had not attained anything like its present perfection, insomuch that it is wonderful how he could do so much with such indifferent instruments, or perhaps with no very great respect for them. Observations of great value, and multitudes of excellent figures, have emanated from many other quarters; but it is contrary to our plan to give anything like a history of the science. References will be found to the most important works in the subjoined catalogues.

278. The following arrangement is essentially that of Fries, only slightly modified as regards the members which enter into the second division.

FUNGALES.	*Sporidiiferi* (sporidia in sacs).	ASCOMYCETES.—Asci formed from the fertile cells of an hymenium.
		PHYSOMYCETES.—Fertile cells seated on threads not compacted into an hymenium.
	Sporiferi (naked spores).	HYPHOMYCETES.—Spores naked, variously seated on conspicuous threads, which are rarely compacted; mostly small in proportion to the threads.
		CONIOMYCETES.—Spores naked, mostly terminal, seated on inconspicuous threads, free or inclosed in a perithecium.
		GASTEROMYCETES.—Spores naked. Hymenium inclosed in a peridium, seldom ruptured before maturity.
		HYMENOMYCETES.—Spores naked. Hymenium free, mostly naked, or if inclosed at first soon exposed.

272. The distinguishing feature in these orders, which are for the most part perfectly natural, is the predominance of the organ from whence the names are taken. Thus, in the first we have in various forms, from that of a cylinder to a wide sac, the ascus or fertile cell, producing one, four, eight, sixteen, or an indefinite number of sporidia from its protoplasm. In the second the origin of the fructification from the protoplasm is less clear. In some it seems to be developed from the tip of the thread which penetrates into the sac or bladder, which constitutes the envelope of the fruit. In the third the *Hypha*, or mould-like mass of threads, is the predominant feature; while in the fourth the threads are only rudimentary, and the spores either very large or very numerous. In the fifth the leading feature is the *Uterus* or general envelope of the sporiferous Hymenium; while in the sixth the *Hymenium* itself is predominant and generally naked, but if covered with a general volva, the covering bursts either just at the maturity of the Hymenium, or while the greater part of the spore-bearing cells are yet imperfect. Their leading features, therefore, may be given after the fashion of Fries in a single word:

1. *Ascus.*
2. *Vesica.*
3. *Hypha.*
4. *Sporæ.*
5. *Uterus.*
6. *Hymenium.*

I. Ascomycetes, *Berk.* (*Endothéques,* Lév.)

Sporidia definite or indefinite, produced from the protoplasm of elongated or dilated cells.

273. The essential character of this important division consists in the development of definite or indefinite sporidia within certain of the external cells of the hymenium called asci, which are frequently accompanied by inarticulate or septate, simple or branched, threads, which are abortive asci, known under the name of paraphyses.

274. There is always something in the shape of a cellular stratum, which produces the asci and paraphyses, and this is

either naked, or contained in a distinct variously shaped cavity, the walls of which often consist of closely compacted cells, whose coats are frequently carbonized, and the apparatus is then called a perithecium. These two conditions are combined with various modifications of the mycelium, and the stroma to which it gives rise; and hence the external form and appearance are often so different as, at first sight, to suggest anything but close affinity, even where undoubted affinity exists. The higher forms are modified again by the circumstance that many species are altogether subterranean in their habits; and as in truly subterranean forms it is all but impossible that the delicate sacs of the hymenium should be developed in immediate contact with the earth, that important stratum, which in allied genera was external, becomes internal by introversion or complication of the walls. It is amongst these hypogeous species that the most beautiful and complicated fruit is produced, affording the most exquisite objects for the microscope.

275. Though the species are numerous, and, doubtless, many of them are wholesome, their size is in general so small as to make them insignificant as articles of food, though there are some eminent exceptions. Others, again, are so hard and tough as to make their consumption almost impossible, though one species, at least, amongst the carbonaceous Fungi, is eaten. Morells and Truffles are well-known objects of luxury, and, whether fresh or dry, always command a high price; and there are some, as *Helvella esculenta* (Fig. 13, *a*), closely allied to the Morell, which are equally good as articles of food. Morells, indeed, are in such demand on the continent, that in some parts of Germany the peasantry were in the habit of burning down large tracts of woodland, having found that the burnt soil is peculiarly productive. This practice existed at one time to such an extent, that it was found necessary to enact laws for its suppression. *Cyttaria* forms an important item in the food of the Fuegians; and *Hypoxylon vernicosum*, the stroma of which may be compared with that of *D'Urvillæa utilis*, is consumed by the Bhoteans in the Himalayas.

ASCOMYCETES.	Asci often evanescent.	*Onygenei.*—Receptacle clavæform. Asci springing from threads which traverse its cavity. Sporidia at length pulverulent.
		Perisporiacei.—Perithecia free, often surrounded by variously shaped threads. Asci springing from the base.
	Asci persistent.	*Sphæriacei.*—Perithecia opening by a distinct punctiform or short linear ostiolum. Asci mostly springing from the walls.
		Phacidiacei.—Hard or coriaceous. Hymenium at length exposed. Disc orbicular or very narrow and linear, surrounded by the obtuse or inflected margin.
		Tuberacei.—Hypogeous. Hymenium mostly complicated.
		Elvellacei.—Carnose, waxy, or tremelloid. Hymenium exposed, very rarely nearly closed.

1. ONYGENEI, *Berk.* (*Onygénés*, Lév.)

General receptacle clavæform or subglobose. Peridium brittle, filled with branched threads, which produce asci at different points. Asci soon absorbed. Sporidia filling the cavity of the peridium, pulverulent.

276. The first group consists of two genera only, one of which is but little known; the other is remarkable for its being developed on animal substances, as feathers, horns, hoofs, hair, &c. I have myself found one species on an old piece of flannel, in Sherwood Forest, which had probably formed part of the dress of some gipsy; and three others, growing on feathers, horns, and bone, have been discovered in this country. One or two are said to grow on wood, but it is not quite certain that they are allied, or if so, the perfect form, perhaps, is not at present known. The species resemble little round-headed nails, and are smooth externally, and filled within with reddish powder, which is at first contained in asci. None of them are very common, and they have scarcely been found out of the northern hemisphere. The species are small, and

of no practical importance, their greatest singularity being their affecting animal substances, and their external resemblance to little puffballs, though differing greatly in structure. In those *Myxogastres*, where a sort of ascus exists, the spores arise from the sporophores, and not from the protoplasm.

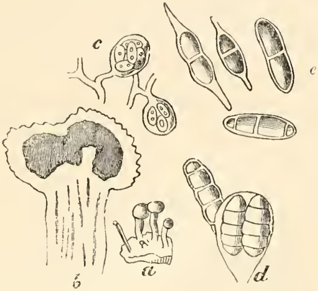

Fig. 62.

a. Onygena equina, natural size.
b. O. corvina, vert. section. Magnified.
c. O. equina, asci and sporidia. Magnified. After Tulasne.
d. Meliola amphitricha, asci and sporidia. Magnified.
e. Meliola cymbisperma, Mont., sporidia. Magnified. Both from specimens in my herbarium.

277. Asci have not always been found. Tulasne was the first to point out their existence; but it is very possible that states may occur in which no asci are developed, but in which they are replaced by naked spores. The peridium often separates from the included mass by a more or less regular fissure.

2. Perisporiacei, *Fr.*

Perithecia free, astomous, at length dehiscent, often surrounded by threads distinct from the mycelium (fulcra). Asci tubular or saccate, often absorbed at an early stage, springing from the base, occasionally solitary.

278. The species of this group are distinguished by the in general great development of the mycelium, their frequently epiphytous habits, the thin brittle walls of the perithecia, and

the tubular or saclike asci springing from the base, and not indifferently from the walls of the perithecium. Most of them grow on living leaves, and are very destructive, either by directly diverting the nutritive juices from their proper office and appropriating them to their own use, or by blocking up the stomates and impeding the free action of the rays of light and of the surrounding atmosphere. A few only occur indifferently on various dead substances, and these approximate a higher group.

279. In an early stage of growth they present the appearance of moulds (Fig. 20, *a*), which is so much the stronger, because the filaments bear reproductive bodies, and sometimes do not advance further. In this condition, they are the plagues of many of our cultivated plants, constituting the mildew of the vine, rose, turnip, &c., appropriating the juices of the plant like true parasites, and in consequence producing disease, and even death. While in some species, however, there is a disposition to preserve this original condition, in others there is almost as strong a tendency to bear fruit. Whereas in the vine mildew no ascigerous sporangia have yet been found, in the hop and pea mildew, the perithecia are almost contemporaneous with the mucedinous fruit, and in consequence there is at one and the same time a double mode of propagation. But, in addition to the mucedinous threads and perithecia, there is a third form of fruit, either resembling the perithecia in outward form, or assuming an ovate outline, with a more or less acuminate apex, in which naked spores of extreme minuteness are produced in numbers almost incalculable. These may possibly be representatives of male organs; but, allowing this to be the case, like such representatives amongst many Algæ, there is much probability that they are reproductive. A fourth form of fruit, similar in essential characters to the third, is formed occasionally within perithecia, resembling exactly those which are ascigerous; and even a fifth occurs, consisting of minute bodies in the organized protoplasm of the moniliform joints of the threads, which spring perpendicularly from the mycelium; joints which under other circumstances are themselves immediately reproductive.

280. One great peculiarity in the genus *Erysiphe*, or the genera more immediately allied to it, consists in the variously shaped processes which at length radiate from the perithecia, and are at the same time altogether independent of the mycelium. Few objects are more beautiful under a microscope of moderate powers (Fig. 64). The mycelium in these species is often pure white, but is sometimes tinged in parts with brown, and occasionally assumes a uniform brown tint, paving the way for *Meliola*. No species of *Erysiphe* is found, as far as I am aware, in very warm climates. They were at one time supposed to be rare in the United States,* but this is far from

Fig. 63.

a. Perithecia of *Capnodium Thwaitesii*, Berk., and a portion of ostiolum. Both magnified. Sent from Ceylon, on the capsules, as it appears, of some *Ardisiad.*

b. Capnodium Citri, producing young and mature perithecia, with a portion yielding the fruit of an *Antennaria.* Magnified. From specimens on imported lemons, and on leaves from Dr. Léveillé.

c. Fertile thread of *Antennaria Robinsonii*, Berk. and Mont. From an authentic specimen.

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* The vine mildew does not occur in the United States on native vines, but only on those which are imported; and the American varieties cultivated in Switzerland and elsewhere, as the Isabella, Catawba, and York Madeira, are uniformly exempt.

being the case. A species was found by Dr. Thomson in Tibet on *Zygophyllum*, and another in New Zealand on *Aristotelia*. Dry weather and warmth, to a certain degree, seem to be favourable to their growth, as is notorious in the hop and turnip mildew; but they do not seem capable of enduring a great amount of heat. The encaustic mycelium of *Meliola* (Fig. 62, *d*, *e*), which grows generally on the firmer leaves, supplies their place in the tropics and subtropics, causing scarcely less damage, where it is prevalent. The sporangia are far larger in this genus, but, like the last, are surrounded by processes springing immediately from their walls. While in *Erysiphe* the sporidia are small, in this they are peculiarly large. With it are associated in the work of destruction, species of *Antennaria*, which are, probably, only the mucedinous state of *Capnodium* (Fig. 63, *a*, *b*, *c*), a genus which is common to warm and temperate parts of either hemisphere. In that genus the perithecia, which are evidently formed or at least incrusted by processes of the mycelium, sometimes yield distinct asci and sporidia; while in other cases they are only pycnidia, and produce naked spores. In *Antennaria*, the sporangioid bodies sometimes contain a ready-formed miniature plant, which waits only circumstances favourable to its expansion. It is curious that, as in *Erysiphe* the pycnidia appear frequently to arise from the transformation of one of the joints of the moniliform threads (Fig. 20, *a*), so the fruit of the *Antennaria* stage of *Capnodium* is a more perfect organization of individual articulations. In both cases the walls, which were originally uniform, become cellular. *Lasiobotrys* differs from allied genera in its subcuticular growth. *Scorias* is an exaggerated form of *Capnodium*, and is gelatinous and very thick when moist. At present it has been found only in the United States.

281. The black mildews have of late years raged to such an extent in the Azores and Ceylon as to threaten the complete annihilation of the orange and coffee plantations, and the ravages have been scarcely less amongst the olives in some parts of Europe. It is impossible that light can have its proper effect through such a medium on the tissues of the

leaves. It would be as rational to expect that plants would thrive under a brown bellglass, as that vegetation should not be impaired where the greater part of a plant is covered with a thick dark felt. The black mildews are often accompanied or preceded by a *Coccus*, and I believe that the first stage of growth of most *Antennariæ* is more frequently observed where the leaves have been soiled with honey-dew.

282. The white mildews, at least, are easily kept under by the application, at a sufficiently early stage of growth of the minute parasite, of powdered sulphur. Its mode of action, probably, depends on the disengagement of sulphurous acid.* The day is not far distant when these affections will be as effectually subdued as the bunt in wheat.

283. The genus *Chætomium* is developed on decaying substances, as paper, straw, &c., or even on old plaster walls, where there can be little organic matter present. The thin brittle walls and mouthless perithecia distinguish it principally from *Sphæria*. The asci in the young plant are evident enough, but they are soon absorbed, leaving behind a mass of very dark sporidia. As in *Meliola* and *Erysiphe*, their walls produce threads which are sometimes amorphous, but occasionally very beautiful in structure. The species occur in various parts of the world, and probably, from their ubiquitous habit, live in great measure on matter derived from the atmosphere. The use of the fulcra in *Erysiphe* and *Meliola*, so variable in form and number, does not seem to be well ascertained. It is very doubtful whether they extract anything from the matrix.

* The crude sulphur, it should seem, combines with oxygen in a nascent state, and so forms sulphurous acid, which is eminently destructive to mucedinous bodies, as appears from its effect in stopping fermentation. The more finely the sulphur is divided the better, and therefore it is most efficacious when applied in such a form as to cause a chemical deposit of sulphur, or, as it is called in the older chemistry, a magisterium on the leaves. (See Gard. Chron. 1855, p. 403.) For this purpose, a solution of sulphuret of potassium is treated with an acid. Liver of sulphur, which consists of tersulphuret of potassium, hyposulphite of potash, and sulphuret of potassium, answers the same purpose. (See also Bouchardat, Traité de la Maladie de la Vigne.)

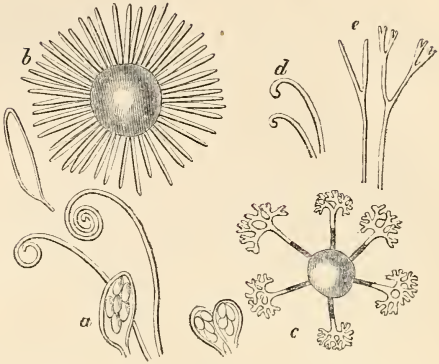

Fig. 64.

a. Fulcra and ascus, with sporidia of *Uncinula spiralis*, Berk. and Curt.

b. Perithecium, with its numerous fulcra and ascus, of *Erysiphe densa*, Berk. and Curt.

c. Ditto of *Microsphæra semitosta*, Berk. and Curt.

d. Fulcra of *Uncinula adunca*, Lév.

e. Ditto of *Microsphæra Mougeotii*, Lév.

All more or less magnified.

From specimens communicated from the United States, by Rev. M. A. Curtis.

3. SPHÆRIACEI, *Fr.*

Perithecia free or immersed in a woody or variously constituted stroma, opening by a distinct punctiform or short linear aperture. Asci mostly springing from the walls, persistent.

284. We come now to an immense group of Fungi, comprising at the least a thousand good species, and possibly double that number. As at present limited, the species are doubtless multiplied beyond all necessity; but an attentive study will at once prove that they must be very numerous. The old genus *Sphæria* (Fig. 65) is now broken up into a large number of genera, but the distinctions are difficult, and by no

means satisfactory, as is always the case, in perfectly natural groups.* The more imperfect forms are those in which no distinct perithecia are formed, with darker heterogeneous walls, the cells of the stroma at once giving place to the hymenium. Such is the character of the genus *Dothidea*, but unhappily it is not always easy to decide whether a perithecium exists or not. The multitudinous forms assumed by those genera in which a perithecium does exist, depend upon the degree of development of the mycelium itself, of the stroma which springs from it, its fleshy gelatinous or carbonaceous texture, and of the contained asci. The simpler species consist almost entirely of perithecium, with a very imperfectly developed mycelium. The latter may, indeed, almost always be traced by the microscope on dissection; but it is often quite invisible even to a good pocket lens. Sometimes they are naked, varying greatly in colour, form, and the nature of the fruit; sometimes they occupy the tender external tissues of decaying twigs and branches, while occasionally they nestle within the hardest wood. In this case the perithecia are sometimes greatly elongated above, like the neck of a bottle, as indeed they are frequently, when immersed in the stroma, or occasionally when quite free. The length of this neck is not, however, always characteristic in the free species, as it depends in some measure on the degree of moisture to which the perithecia have been exposed; and M. Duby states that he can at pleasure produce this elongation in species which are ordinarily short-necked. If the mycelium is much developed we have the byssoid *Sphæriæ*. The elongation or distortion of the orifice by which the sporidia are discharged affords excellent sectional characters. Sometimes the perithecia are aggregate and crowded, on a distinct coloured sporiferous stroma, constituting the genus *Tubercularia*.

285. The stroma may be developed in various degrees, being more or less intimately incorporated with the bark, or it may be quite free, assuming various degrees of consistence, and, according to its mode of expansion or elongation, affording very

* *Xylaria pedunculata*, Sow., t. 437, is sometimes reduced to a single sessile perithecium, when it is *Sphæria stercorarea*, t. 357.

excellent characters. Thus we have the multitude of pustular or stromatic species, which grow on the branches of trees, or on decayed wood; while the more elongated clavate or simply globose forms yield the species of *Hypoxylon* and *Cordyceps* (Fig. 17, *b*). Some of the most beautiful and remarkable are those which grow on insects. *Cordyceps Robertsii*, which grows upon the larvæ of *Hepialus virescens*, is well known to every one who has seen or received specimens of the productions of New Zealand. But this is far exceeded in size by a species which grows on an enormous larva or the banks of the Murrambidgee, of which, at present, immature specimens only have been examined. Most of the larvæ which produce insects probably carried the seeds of the disease with them into their subterraneous retreat; and in one species, at least, which affects wasps, the clubs with their curled stems are carried about till the unhappy insect sinks under the exhaustion produced by the waste of its fatty tissue.

286. As regards their geographical distribution, it may be asserted that *Sphæriæ* are to be found in almost every part of the world. When the air has the proper degree of moisture, they are most abundant in temperate climates, but they are by no means wanting in the tropics, especially such forms as approximate to *Xylaria hypoxylon*, which is one of the most cosmopolitan of plants. The finest forms, indeed, are found in the warmer countries. In New Zealand, species resembling those of the northern hemisphere are not uncommon, and we have a few species from most hot countries. In some, as in Cayenne, they are exceedingly abundant, the forms being frequently peculiar; while some of the species are so singular that at first sight they would scarcely be recognised as Fungi, resembling far more a sort of black caddis case which was once described as a *Dentalium*, and figured as a doubtful species by Sowerby in the Genera of shells under *Dentalium* (Fig. 9). But even in temperate climes they are not always very prevalent. Amongst the Sikkim Himalayas, for instance, very few species were collected by Dr. Hooker, though his attention was turned to every part of the vegetable world, and many species of far greater obscurity are comprised in his collections. Such com-

paratively rare species as *Hypoxylon vernicosum* are sometimes very widely diffused. It occurs in the south of Europe, in North America from Ohio downwards; and it again turns up in the Himalayas above Sikkim, scarcely altered in form. The insect *Sphæriæ* again occur in very different realms, though not always under the same species. China, Khassya, Australia, New Zealand, the West Indies, North America, and Europe, all produce their kinds, and that upon insects of extremely different affinities. There are other fleshy *Sphæriæ* which resemble greatly the insect species, but differ totally as to habitat. We have two species which grow on *Elaphomyces*, one of them of considerable size, but nothing with a similar habit occurs in the southern hemisphere. One or two similar though smaller species grow upon Ergot, of which they seem beyond doubt to be the ultimate development. To

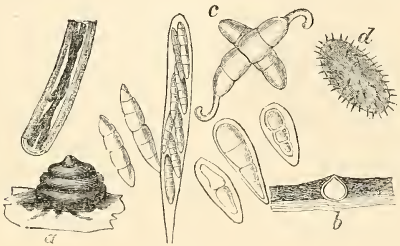

Fig. 65.

a. Sphæria pulvis pyrius. Perithecium, ascus, sporidia, and mycelium, threading the woody fibres of the plant on which it grows.

b. Sphæria amblyospora, Berk. and Br. Section of perithecium immersed in bark and sporidia.

c. Sporidium of *Sphæria inquinans*, with its appendages, and of *Stilbospora macrosperma.*

d. Sporidium of *Tuber melanospermum.*

All more or less magnified.

obtain them it is merely requisite to place the ergot in soil kept moderately damp, but not so damp as to encourage mould, and after a few months there is a tolerable certainty of a crop.

287. The identity of ergot with *Cordyceps* has been called in question by Cesati, because two species of *Cordyceps* occur occasionally on the same kind of ergot. Mr. Currey has lately forwarded to me specimens of *C. purpurea,* on the ergot of the common reed, which usually produces *C. microcephela.* But it is very possible that the same grass may be ergoted by more than one *Cordyceps;* and even should a single ergot be found to produce two species of *Cordyceps* at once, it is possible that the sporidia of the two species may have concurred in its production.

288. A volume might be written on the different forms of *Sphæriæ,* their peculiarities, and their fruit; but our limits and object require brevity. The point in view is merely to give general notions, which may afterwards be applied in practice.

289. It has been stated that the peculiar character of *Ascomycetes* depends upon the presence of asci containing sporidia, but it is quite certain that in many cases perithecia occur containing naked spores totally different in form from the sporidia, though sometimes closely resembling them. In some cases, again, spores are formed immediately beneath the cuticle of the matrix without any perithecia, which may either differ entirely from those of the ascigerous plant provided with a perithecium, or may closely resemble them, as in *Sphæria inquinans* (Fig. 65, *c*), where the one is distinguished from the other merely by the presence of an appendage at either extremity.

290. This dualism has given rise to the formation of numerous genera; and in point of fact, under our present state of knowledge, it is impossible to say whether such genera as *Sphæropsis, Diplodia, Septoria,* &c., are ever autonomous. On the same twig perithecia occur perfectly alike, though totally different as regards fruit, and which it is impossible to distinguish without microscopic examination. One of the best examples is, perhaps, *Sp. mutila,* with its numerous allies, all of which at times produce naked spores as well as asci. At present, I am by no means inclined to give up the whole mass of sporophorous *Sphæriæ* as mere secondary forms of fruit, the ascigerous form being that which is normal. Besides

these stylospores, conidia are frequent on the mycelium. *Haplosporium*, Mont., which grows upon bulbs in North Africa, is remarkable for containing only a single sporidium in each ascus. *Sphæria Posidoniæ* grows on the African coast, on the roots of *Posidonia*, where it is constantly subject to the action of salt water; and *S. herbarum*, which affects plants of widely different genera, has been found on decaying seaweeds.

291. *Thamnomyces* is remarkable for the extremely slender forms assumed by the stroma in many species, in some of which it is very brittle, and in one curiously annulated. Most of them are tropical species; but one is not uncommon in this country, on decaying mats made of *Scirpus lacustris* or on hemp sacs. In those species which I have examined, there is no true perithecium, and the asci are more rapidly absorbed than in normal *Sphæriacei*. In *Micropeltis* the perithecium is extremely flat, and the asci all radiate from a central point. The species are tropical, but are represented in temperate countries by species of *Microthyrium*, which perhaps is not sufficiently distinct as a genus. The whole tribe yields scarcely a plant of any utility. *Hypoxylon vernicosum* is a bad article of food, and *Cordyceps sinensis* a drug of doubtful virtues. Their great end seems to be the decomposition of hard tissues and the nourishment of thousands of insects.

4. Phacidiacei, *Fr.*

Hymenium at length more or less exposed; disc orbicular or linear; margin generally involute; walls coriaceous.

292. The foregoing division was distinguished by its more or less spherical perithecia, assuming sometimes a compressed outline, from lateral pressure either of the fibres of the matrix, or of neighbouring individuals crowding in upon each other, but by no means deviating normally. The aperture was for the most part minute and circular, or, if linear from their characteristic form, it was very short, and arose from the compression of the orifice. We have here, on the contrary, highly elongated and even branched perithecia, or where the normal form is circular it is in general rather orbicular than spherical, in consequence of the widely expanded aperture exposing the hymenial surface to the action of light, insomuch that it assumes

various colours, as green, purple, vermilion, &c., a circumstance which never takes place amongst the *Sphæriacei*. In the linear species the form of the aperture depends upon the form of the perithecium, or excipulum, the margins of which are rounded. In other cases, however, the disc is exposed by the mere fissure of the walls, as in *Phacidium*, and this fissure may either be simple or compound, radiating from a central point and forming triangular lobes.

Fig. 66.

a. Hysterium Fraxini, P. Perithecium entire and divided vertically, with ascus and sporidia.

b. Phacidium Delta, Kze. Perithecium and asci with sporidia. From specimens gathered in Madeira by the Rev. R. T. Lowe.

c. Ascomyces bullatus, Berk. From the ninth volume of the Journal of the Hort. Society of London.*

d. Vibrissea truncorum, Fr., nat. size, and sporidia. From a specimen sent by Rev. T. Salwey, from Llyn Howel.

293. The species are numerous, but by no means so multitudinous as the *Sphæriacei*. The walls of the perithecium are either carbonaceous or cartilaginous, and very rarely soft, in which case they must be separated with caution from the *Pezizæ*. When the hymenium is well exposed, as in *Cenan-*

* A species of this genus distorts the leaves of peaches in a most extraordinary way. The increase in thickness is caused by the interposition of eight or more strata of merenchymatous cells between the cuticular stratum, and the oblong close-packed cells, which in healthy peach-leaves follow it. At the same time the intercellular spaces of the lower part are narrowed as the leaf contracts.

gium, it is usually of a brighter colour than the walls, the contrary to which obtains in *Pezizæ*. The greater number grow on wood or dead vegetable productions; but a few, as *Labrella Ptarmicæ*, occur on living leaves. The whole plant in this case seems to be traversed by the mycelium; for if a plant thoroughly infested by it be taken to a distance, it produces for some years in succession a fresh harvest, even in countries where the species is unknown in a wild state. This was the case with plants brought by me from Lille, in 1837. *Cordierites* approaches in form to some *Hymenomycetes*, and may be compared with *Guepinia*. *Phacidiacei* abound in many parts of Europe and America, but are rare elsewhere. *Cordierites* is the only form peculiar to the tropics or sub-tropics. A species was found by Spruce on the Rio Negro, a tributary of the Amazon, nearly allied to *Peziza irregularis*, Schwein, which appears to belong to the same genus, and to affect the highest latitude of any known species. *Glonium* occurs not only in several of the North American states, as far down as South Carolina, but I have specimens from Sweden. New Zealand has one or two species in common with the warmer North American provinces, or even with Surinam. Stylospores, accompanied sometimes by spermatia,* occur in some of the species. In *Tympanis* (Fig. 60, *c*) two modes of fructification have been seen in the same hymenium, the one resembling *Diplodia*, the other consisting of asci, containing an indefinite number of sporidia, and it is probable that in such species there are also asci containing a definite number of sporidia. The asci of *Aylographum* are remarkable for being very short and nearly globose. The old *Hysterium rugosum* (Dichæna) assumes a multitude of forms with very different fruit, and it is probable that all of these are mere modifications of one common species. The species are in general far too small to present any article of food, and I know of no useful purpose to which any of them are applied.

5. TUBERACEI, *Fr.*

Hypogeous. Hymenium mostly convolute, and, by confluence, forming veins in which the asci are irregularly distributed.

* Tul. in Ann. d. Sc. Nat., sér. 3, v. 20.

294. We come now to a very important division, both on account of the value of many of the species, and of the singularity of their habit and structure.* With the exception of *Endogone* and *Sphærosoma*, they all grow more or less completely beneath the surface of the soil, and *Endogone* is, in fact, a condensed *Mucor* and *Sphærosoma* little different from a spherical *Helvella*. In consequence of their subterranean mode of growth the hymenium is internal, even in those species which are most nearly allied to others with exposed hymenia, which grow in the open air. Some are, in fact, little more than closed *Pezizæ*, as *Genea* and *Hydnocystis*. Indeed, there is a small group of *Pezizæ*, which grow in sand or on loose earth, as *P. sepulta*, *affinis*, and *arenicola*, in which the cups are more or less buried. These species are scarcely distinguishable from *Hydnocystis*. In some the cavity is quite simple; but in others, from the protrusion and depression of parts of the walls, it becomes irregular. In the more compact and solid species, either the mass is traversed by flexuous cavities, the walls of which constitute a more or less distinct hymenium, or the cavities are quite obliterated, and the mass presents a marbled section, the lighter parts of which consist of a kind of stroma, while the darker are speckled with sporangia immersed in veins, which arise from two confluent hymenia placed front to front. In the species which are more nearly allied to *Pezizæ*, the asci are often cylindrical, and the sporidia of moderate dimensions, though often curiously sculptured; but in the real truffles the asci are represented by large pyriform sacs, and the sporidia are large, with a reticulated and sometimes spinulose episporium (Fig. 65, *d*). In some cases, as in the red truffle, the episporium is of considerable thickness, and the cells very large and loose. They afford beautiful objects for the microscope, but they often

* Those who wish for full information respecting these plants must consult the splendid work of Tulasne, which leaves scarcely anything for future observers, whether as regards morphology, history, or physiology. The British truffles have been most successfully investigated by Messrs. Broome and Thwaites, to whose researches a long list both of genera and species is due. Their work was so well performed that no new British species has occurred very lately.

require some study to obtain an accurate knowledge of their structure. The supposed spines, for instance, with which many are said to be covered, are sometimes nothing more than the angles of contiguous cells. *Elaphomyces* is remarkable for the walls of the asci being absorbed at a very early stage of growth, while the hymenium dries up; so that the cavity of the plant is filled with a dusty mass of spores mixed with a few threads. They were once in consequence associated with the puff-balls, to which they have no affinity.

295. The *Tuberacei* are perhaps improperly placed in a distinct division, as their characters are derived from their place of growth rather than from any essential diversity of structure, and they have no relation except one of analogy to the numerous subterranean Fungi, which will come under review in a future division. They have long attracted notice from their mode of growth, and for the exquisite flavour of many of the species, which makes them bear a large price in our markets, insomuch that they are sometimes an important article of commerce. They are, perhaps, far more common than is generally supposed; but they are difficult to find, or overlooked in consequence of their place of growth, and the aid of trained dogs or other animals is necessary where large supplies are wanted. *Tuber æstivum* is almost the only species which appears in our markets; but in France the far more highly flavoured *T. melanosporum*, the exquisite *T. magnatum*, and some other species, are commonly consumed. Their cultivation has hitherto not been attended with the same success as that of the mushroom, though many attempts have been made. The matter is, however, by no means beyond hope, especially since attempts to make the mycelium run have been crowned with success.

296. Truffles are for the most part found in calcareous ground. In some parts of France, as in Poitou, it is simply necessary, in order to their supply, to inclose a spot on the calcareous downs, sowing it with acorns. As soon as the saplings attain a growth of a few years, the truffles appear, and a harvest is obtained for many years successively without further pains.

297. Truffles require a temperate but by no means a cold

climate for their growth. They have been found in England as far north as Rutlandshire; and in Northamptonshire numerous species occur; but they are more abundant as we proceed towards the south, and attain their maximum in Italy. In Sweden they are very rare. Several occur in Algiers; and one is abundant, having been long known as an inhabitant of Africa. In the United States they are very rare, and scarcely differ in species from those of Europe. Several species have been found by Mr. Drummond about the Swan River, but at present specimens have not been received in a sufficiently good state for description. The curious genus *Paurocotylis*, Berk., occurs in New Zealand, being remarkable for its bright colour, and *Mylitta*, which is sometimes several inches across, is abundant in some parts of Australia, where it is eaten by the natives. Fresh specimens have a subacid smell and little taste; but we have seen others of an extremely compact horny texture, resembling a mass of sago forcibly compressed into a solid ball. The Tuckahoo of the Americans is not a true fungus, but a state of certain unknown roots in which their substance is converted into pectic acid, while some of the large tuberous masses which occur in tropical climates are merely dormant states of Fungi. The *Pietra funghaia*, of which I have a fine specimen, and which has been conjectured to be a sort of truffle, is certainly nothing more than the mycelium of *Polyporus tuberaster* traversing balls of earth, which it has the property of collecting about it in a compact form. Medicinal properties were long supposed to belong to the truffles, and more especially to *Elaphomyces;* but their virtue is very doubtful, and probably, as in so many other cases, arises merely from the doctrine of signatures. The truffles are principally used as condiments, but simply roasted like a potato they are excellent, and not so indigestible as when sodden in wine or water.

6. ELVELLACEI, *Fr.*

Hymenium often open from the beginning, very rarely closed; substance fleshy, waxy, or tremelloid, rarely subcoriaceous; cup-shaped or clavate.

298. The grand characteristic of this large group of Fungi

is the fleshy or soft texture, and the more or less early and complete exposure of the surface of the hymenium. In the more perfect species, there is in no stage of growth the slightest tendency to form a cup; but even these are so intimately allied with the more noble *Pezizæ*, that it is a matter of some difficulty to distinguish certain states of *Peziza macropus* and *Helvella elastica* (Fig. 13, *c*, *b*). In *Burcardia* and *Cyttaria* the cups are quite as hollow as in *Sphæria*, and in the latter (in one species at least) almost as much closed; and in these genera there is a peculiarity of texture separating them in some measure from the others of the section, though connected by *Bulgaria*. The sporidia vary very much in form, and some-

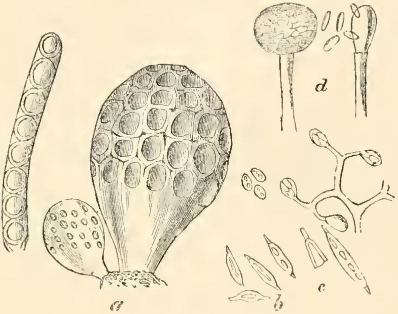

Fig. 67.

a. Cyttaria Gunnii, Berk., nat. size, young and old, with ascus magnified. From specimens communicated by Sir W. J. Hooker.

b. Spores of *Rhizina zonata*, Berk., magnified Gathered in Sikkim by Dr. Hooker.

c. Ditto of *Rhizina undulata*. From South Carolina, by Rev. M. A. Curtis.

d. Ascophora elegans, Corda. From specimens gathered at King's Cliffe. Above is the vesicle filled with oblong spores, the columella, and the spores; below, the secondary fruit, each vesicle containing a very few spores, which are shorter and broader.

times approach in appearance those of such truffles as *Genea;* and there are species of *Peziza* which are essentially subterraneous in their mode of growth, as *P. sepulta*, which occurs in myriads every year about Upsal, and has been found by Dr. Badham in Suffolk. It is known at once by its coarse woolly coat, soiled with fragments of earth or sand, by its globose form, and the imperfect exposure of the hymenium. *Hydnocystis* is, in fact, very near to such *Pezizæ*, though essentially distinct and far more neat in habit.

299. The large genus *Peziza* embraces many of the most elegant Fungi, from the little white and red *Peziza elegans*, which is sprinkled over almost every fallen twig of the larch and other conifers; the pale toothed cups of *P. oronata*, which abounds on dead stems of herbaceous plants; the scarlet *P. scutellata*, with its edge fringed with tawny hairs; the graceful mousegrey *P. macropus*, to the gorgeous *P. coccinea*, which attracts the notice of children from its elegant form and bright colour; the more irregular but not less brilliant *P. aurantia*, and the font-shaped *P. acetabulum*, which might form an elegant pattern for the architect or silversmith. Fifty others might be mentioned of equal pretensions to elegance of outline and brilliancy of colouring, especially if the exotic allies of *P. coccinea* be taken into account, as *P. floccosa* of North America, with its delicate hairs, like those of some sallow or *P. tricholoma* and *hystrix* bearded like the pard.

300. In *Helvella* (Fig. 13, *a*, *b*), the cup is inverted, so as to form a sort of mitre-shaped or ovate pileus, with the margins free in some species, but in others more or less perfectly attached to the stem; in some the head thus formed is lobed, so as to resemble a mitre. When the cup and stem are perfectly soldered together, we have the clavate species of the group. In *Spathulea* the stem is still visible on one side through the greater part of the pileus, and the consequence is that the hymenium assumes a spathulate form or that of a battledoor. Its elegant buff tint and curious shape render it highly attractive. In *Mitrula* and *Leotia* we have distinct stems, with a sub-globose head more or less intimately connected with it. *Mitrula paludosa* is remarkable for its always growing on leaves or other vegetable remains rotting in water. Its scarlet head and white delicately tinted stem make it a most charm-

ing object. In other cases the stem is so confluent that thus we have forms, as *Geoglossum difforme*, not distinguishable from true *Hymenomycetes* except by their mode of fructification. Still, another form or two are produced by the multiplication of the hymenial surface through inequalities which were first shadowed out in *Peziza venosa*, and these in the common morell are increased to such an extent as to represent deep pits like those of a honeycomb.

301. There is a lower series, where the cup is obliterated simply by expansion, the attenuation of the margin, and the flattening of the hymenial surface. Such forms are represented by *Propolis* and *Cryptomyces*. The change from the cupulate to the clavate form takes place in two directions from *Peziza;* first, amongst the higher species, which are confluent with *Helvella*, and, secondly, amongst the lower species, which are confluent through *Helotium*, a sub-genus of *Peziza*, with *Vibrissea* (Fig. 66, *d*).

302. A few of the *Pezizæ* not only loose entirely their cup-like form, but become confluent at the margin, as *P. confluens*, and thus produce a nearly uniform stratum, which is distinguishable from similar *Hymenomycetes*, as *Corticium*, only by the fruit. This paves the way to the genus *Psilopezia*, which is totally destitute of margin, and is, in fact, an ascigerous *Corticium*, or to *Rhizina*, remarkable for its tufts of roots and curious sporidia (Fig. 67, *b*). A far more degenerate form of *Ascomycetes* occurs on leaves, causing them to swell and blister, as in the peach, walnut, and pear, consisting of little more than asci, accompanied by very short moniliform threads. This is the genus *Ascomyces*, one of the most obscure amongst Fungi, but from its structure and effect on vegetation not devoid of interest (Fig. 66, *c*).

303. Tulasne* has shown that there is a second form of fruit in some genera, as, for example, in *Bulgaria*, of the present division; *Cenangium*, *Tympanis*, and *Dermatea*, of the foregoing.† These bodies are variously situated and shaped, and

* Ann. d. Sc. Nat., sér. 3, v. 20, p. 129.

† In *Cyttaria Darwinii*, Berk., there are little black specks on the base, which will probably prove pycnidia or spermatogonia.

are the fruit of *Sphæropsis*, or other *sporoferi*. Besides these, or in their absence, as in *Peziza*, he has discovered minute bodies which he considers to be *spermatia*. These are sometimes contained in distinct organs, sometimes they accompany the ordinary fruit. At present their functions are obscure. As regards the binary fruit, Fries long ere this had pointed out the identity of *Fusarium Tremelloides* and the orange-coloured *Peziza*, which is so very common on decayed nettle stems. Now the binary or even quinary mode of fructification in some Fungi is established, no good botanist can doubt their identity; but it is yet to be shown that any of the bodies in question are entitled to be compared with spermatozoids.

304. The remarkable elastic force with which many of the larger *Pezizæ* and *Helvellæ* eject their sporidia has often excited attention. In none is it better seen than in the common *Peziza vesiculosa* of the hot-bed when the sun is shining. The least agitation raises a visible cloud of sporidia like a thin vapour. The motion of the sporidia in *Vibrissea*, a genus which grows on twigs immersed partly in water, is very peculiar. They are extremely long and slender, and when partially ejected wave about in the sun till they are finally expelled. The phenomenon is due to their extreme length, which does not allow them to be expelled at one effort (Fig. 66, *d*).

305. A few of the species of this group afford excellent articles of food. Morells are found in some parts of England in such abundance as to make their collection for the oilmen worth notice, and even to afford large supplies of an excellent katsup. The principal part, however, of the Morells of commerce is not of home growth, but comes from Germany and other continental countries. In the former country, they were observed to affect more especially places where wood had been burnt, and the collection was so lucrative as to induce the peasants to destroy the forests by fire, with a view to favour their growth, a practice which was at last checked by the enacting of especial laws. In the north of India, as in Kashmir, Morells are collected both for food and sale; and the species which I have had an opportunity of examining do not seem to differ from the more common natives of Europe. One

or two species of *Helvella*, especially *H. esculenta*, are considered excellent food. I have seen *Peziza venosa*, or some large allied species, offered for sale under the name of Morells in Northamptonshire, and have never heard of any evil consequences arising from their use, but they have not the aroma of the true morell, but an odour approaching that of nitric acid, which is not any strong recommendation.

306. The most important genus of the group, as regards alimentary qualities, is undoubtedly that of *Cyttaria* (Fig. 67, *a*), because it is the staple food of the Fuegians during many months of the year. The species have the great peculiarity of growing upon living branches, after the fashion of the jelly-like fungus of the Juniper; and the sub-gelatinous consistence indicates nutritive qualities superior to that of others of the group, and like so many other nutritious matters it seems to be insipid. It has not been analysed at present, so that nothing can be said about the principle on which its superior nutritive qualities depend. Where Fungi form a large portion of the food of the people, it is in general a sure indication of an unproductive climate, or an extremely depressed peasantry; but it is possible that the qualities of *Cyttaria* may really be superior to those of other fungi, arising probably from its immediate imbibition of the elaborated gummy sap of the matrix.

307. *Cyttaria* is confined to a portion of the southern hemisphere. There is a species very circumstantially marked by Commerson, in Delessert's Herbarium, as gathered in the Isle of France. But no evergreen beech grows there, and the genus is found on no other kind of tree. A few of the finer *Pezizæ* affect tropical climates only, but the number of species is not large which are peculiarly addicted to warmer latitudes, and even these have in general close allies elsewhere. One of the very finest, *Peziza macrotis*, distinguished by its elongated ear-like form and firm substance, is abundant in the moist region of Sikkim, and this also has its representatives in Europe in *P. onotica* and *leporina*. *Rhizina*, *Leotia*, and *Geoglossum* occur in Sikkim; *Morchella* in Kashmir; and the greater part of the genera are diffused through the United States.

II. Physomycetes, *Berk.*

Fertile cells bladdershaped, scattered on the threads, which are not compacted so as to form a distinct hymenium. Sporidia indefinite, formed from the protoplasm of the cells.

308. This small but curious order is exactly intermediate between *Ascomycetes* and *Hyphomycetes.* It agrees with the former in the free development of its sporidia within a closed sac, though this sac is more globular than in the more typical species of that order. With the latter it agrees in the free fertile threads, which are peculiarly delicate and never compacted, so as to form an hymenium. It is to be observed, however, that in *Acrostalagmus,* which appears to be a secondary form of *Trichothecium,* or rather *Dactylium,* the reproductive bodies grow from the apex of the peduncle, which protrudes into the cyst, a circumstance which might be fatal to the separation of these Fungi under a distinct head, were there not other instances in which a sac incloses true spores, as, for example, in *Badhamia* and *Enerthenema,* amongst the minute puff balls, and also in a species of *Hymenogaster,** one of the hymeniferous truffles. If the point could be established, that the same structure prevails in such genera as *Mucor* and *Ascophora,* the order would, doubtless, merge into *Hyphomycetes;* but there is no evidence to this effect, though in many cases a distinct columella, the tip of the fertile thread, projects into the vesicle.

309. Species occur probably in almost all parts of the world on decaying or decomposing vegetable matter, but few exotic forms exist in our Herbaria, as they are often neglected by travellers, and are preserved with difficulty wherever the atmosphere is moist, being peculiarly liable to be attacked by mites. A species of *Mucor* was collected in Cuba, by Ramon de la Sagra; several genera were found by Martius, in Brazil; and I have many species from the hotter parts of the United States. No species appears in the Floras of the Antarctic regions and New Zealand, but I do not doubt their existence

* See Tulasne, Champignons Hypogés, tab. x., fig. 1, under *Hymenogaster tener.* The same curious appearance has been seen also by myself and Mr. Thwaites.

there, though none appears to have been collected by Bertero, who was a very close observer, in Juan Fernandez. If, however, *Antennaria* were still included, we should have abundant representatives, but that genus is evidently a mere condition of *Capnodium.*

310. The species, like the greater part of moulds, occur on decaying substances, and frequently on such as are used by man for food. In some instances, perhaps, as in the bread-mould, the germination of the spores induces decay, and certainly accelerates it. The part they perform in the decay of fruit has already been mentioned. If *Endogone* really belongs to this group, there are one or two subterranean species, differing from the others in their compact habit, though still forming nothing like an hymenium. But the contents of the vesicles in that genus are still imperfectly known. The aquatic moulds which have been described under Algæ (p. 131), will, in all probability, finally find their resting-place here, and if so, will present the singular anomaly of true zoospores amongst Fungi. Some species of *Mucor*, like *Penicillium*, promote fermentation. A case in point is recorded in Mag. of Zool. and Bot., vol. 2, p. 340, with a figure of the mycelioid state which *Mucor clavatus* assumed when developed, in enormous quantities, in raisin wine. The wine, it should be observed, so far from being deteriorated, was of peculiar excellence.

311. Whether *Achlya* and its allied genera be moulds or not, a very singular phenomenon takes place in the genus *Syzygites,* which has its parallel only amongst Algæ. The mould is common upon decaying Agarics in woods, and may easily be observed in all its stages of growth at home, if kept in a moist atmosphere. The erect fertile threads soon throw out little tubercles from their forked or forcipate tips. The tubercles, like the connecting tubes of *Zygnema* (p. 152), soon touch each other and coalesce; a dissepiment is formed on either side, the two intermediate membranes at the point of contact are absorbed, and, finally, the united cells swell, and form a single irregular sac, which soon produces an abundance of sporidia. Extremely active molecular motion has been ob-

served by myself in *Endodromia*,* and in *Pilobolus*, Ehrenberg and Müller have recorded a curious motion in the dew drops, with which the species are so often studded, without, however, giving any satisfactory account of the nature of the moving body.

1. Mucorini, *Fr.*

312. When *Antennaria* is removed, and the two imperfectly known genera, *Pleuropyxis* and *Pisomyxa*, there remains only the group of true moulds, than which nothing can be a more natural assemblage. Most of their peculiarities have already been mentioned. *Phycomyces* is one of the most remarkable for its size and rapid development. It grows on walls saturated with oil, or upon grease, where it occurs in prodigious quantities. It is, in fact, an exaggerated form of *Mucor*, remarkable for the green colour and shining aspect of the stem when dry, which seem at first to indicate affinity rather with Algæ than Fungi, as indeed the name implies. This genus has, moreover, not the slightest affinity to *Stilbum*, with which it was long improperly associated.

313. Some species of *Ascophora* bear two distinct kinds of fruit on the same stem. This is the case with *Ascophora elegans*, one of the most beautiful of Fungi, a portion of which is represented (Fig. 67, *d*). Not only are the two kinds of vesicles different, but also the contained sporidia. *Pilobolus* is remarkable for the inflated stem, on which the fruitbearing vesicle is seated like a gem in a die. The eggs of *Hemerobia* are at first sight extremely like a *Mucor*, and are figured as a mould by more than one Botanist.

III. Hyphomycetes, *Fr.*

Spores naked, growing upon the fertile threads, simple or compound. Threads white, dark brown, or coloured, very rarely so compacted as to present anything like an hymenium.

314. It was stated that there are two main types of fructification, the sporophorous and the ascigerous, characterising

* Berk. in Hook. Journ., vol. iii., p. 78. Kze. Myc. Hefte., ii., p. 67. I have seen exactly the same motion in little cells in the endochrome of Brocoli, affected with the disease called clubbing. A figure will be found in Gard. Chron., p. 500, 1856.

respectively those Fungi which bear naked spores, and those which bear sporidia in asci. We have seen that many of the ascigerous Fungi bear a second form of fruit, which consists of naked spores borne on the tips of sporophores; and in some cases other forms of fruit occur, as in *Erysiphe* and its allies. In *Physomycetes*, two sorts of cysts grow sometimes on the same thread, with sporidia of different kinds in either cyst. It will be seen, again, in the order which we have now under consideration, that more than one form of fruit occurs. Sometimes we have merely a second kind of naked fruit, but there are other cases also where there is a regular sporangium. Such observations are, however, in their infancy; and there seems to be such a regular gradation from the humblest mould to the noblest Agaric, that I cannot induce myself to regard the sporangium as the higher fruit, and the spores as subordinate, though there can be no doubt that in many *Sphæriæ* such a condition holds good. The naked spore, indeed, being the normal fruit of the noblest Fungi, must be regarded as indicative of higher station, even though the ascigerous form, considered simply as fruit, be supposed to have the greater dignity. It will be seen, again, when we get to higher Fungi, that we have occasionally spores inclosed in cysts, where there can be no doubt whatever as to affinity.

315. The species contained in the division *Hyphomycetes*, consist of Fungi which, like *Mucorini*, are known under the common name of moulds. All organised matter is soon compelled by their agency to undergo chemical change, or when chemical change has taken place supplies a fitting matrix for their development. The common blue mould of cheese, the brick red cheese mould, and the scarlet or orange strata which grow on tubers or roots stored up for use, when commencing to decay, are familiar examples. Nothing, however, escapes their ravages. The silk or cloth stored up in our wardrobes, the meal and sugar of our kitchens, nay, the very glass of our windows, suffer in greater or in less degree. In a few cases, as in cheese, their growth is encouraged, and steps are even taken to inoculate untainted cheeses; but in other instances they are a destructive poison, unless, indeed, the evil effects

Fig. 68.

a. Aspergillus glaucus, with its echinulate spores.

b. Aspergillus dubius, Corda, with the processes from which the necklaces of spores arise.

c. Penicillium armeniacum, Berk., with its elliptic spores connected by little processes.

d. Sepedonium mycophilum.

e. Helminthosporium nodosum, Berk. and Curt. Sent from South Carolina, on *Eleusine Indica*, by Rev. M. A. Curtis.

f. Spore of *H. Hoffmanni*, Berk. and Curt. From specimens on *Sporobolus Indicus.* Sent by Rev. M. A. Curtis.

g. Tip of thread of *Zygodesmus fuscus*, with its echinulate spores.

All more or less magnified.

which have arisen from the use of certain mouldy provisions are to be ascribed to the decomposition of the matrix, rather than to the mould itself. Some of the species are developed with extreme rapidity, and a few years since, when the barrack bread was so much affected at Paris by a species of *Penicillium*, a very few hours were sufficient for its development, and the mould was in active growth almost before the bread was cold. Indeed, it was proved satisfactorily that the spores of this species are capable of enduring a temperature at least equal to that of boiling water, without losing their power of germination. Such facts, then, are no proof of spontaneous or equivocal generation. Dutrochet found, indeed, that the chemical nature of substances had great influence on the species which grow upon them, and that albumen was almost a perfective preventive. This, however, is simply in accordance with facts relative to the distribution of Phænogams over the surface of the earth. The chemical composition of the soil has a great deal to do with that distribution. The occurrence of moulds in closed cavities has been mentioned above, and the extent to which the spores or other reproductive bodies insinuate themselves in the most deeply seated tissues. Dutrochet professes to have seen milk globules changed into the spores of moulds, or at any rate developed into moulds. Certain it is, that when milk is arrested for a long time in the udder of the cow,* and forms clots there, moulds are frequently found, and that they find their way into cavities which are almost closed to external influences, as in the urinary bladder of man, and that under more than one form. Such anomalies may at first surprise us, but they may, nevertheless, admit of explanation, as the presence of the larvæ of Tapeworms in deep-seated organs, and even in the brain, which was so long a stumbling-block of science. On surfaces freely exposed to the air, as the pulmonary cavity, or communicating with it occasionally, as the walls of the stomach, they are not unfrequently developed, under peculiar conditions of disease.

316. One of the most remarkable qualities possessed by certain moulds is the power they have of producing or accelerating fermentation. Yeast is, in fact, nothing more than a peculiar condition of a species of *Penicillium*, which is capable of almost endless propagation, without ever bearing perfect fruit. Attempts have been made to show that the structure of yeast globules is different from that of ordinary moulds, but without success.† It appears that wherever exosmose and endosmose take place, there is chemical action; and thus, when yeast is mixed with any saccharine matter, a multitude of points are presented at which an active interchange is going on between the contents of the globules and the external fluid, and at which chemical action can take place. The process is only accelerated by the presence of the ferment, or rather the fermentation is regulated, and the putrefactive and acetous fermentation which might otherwise be established, effectually

* Turpin, Mémoires du Mus. d'Hist. Nat., 1840.

† See Article "Yeast," in Morton's Encyclopædia.

controlled. Under proper conditions of temperature, the acetic fermentation will take place on the application of yeast, but not so surely or speedily as by the mycelium of the *Penicillium*, which is known under the name of the Vinegar plant, a filamentous condition instead of a vesicular.

317. The production of yeast depends upon the extreme facility with which moulds adapt themselves to peculiar circumstances. The proper position of such moulds is upon the surface of decaying substances; but several species are capable of sustaining life when completely immerged. In such a condition they cannot produce any real fruit, but they are propagated by means of shoots from the mycelium. Substances, which would prove fatal to many other vegetables, as solutions of arsenic, opium, and many other poisonous chemical substances, do not prevent the growth of moulds. One form proves an intolerable nuisance in electrotyping, being developed in the solution of copper used in that process, and becoming itself eventually thoroughly electrotyped. Under such circumstances, they have the power of separating the metal or other noxious principle, while they avail themselves of any nutritive matter with which it may be combined. These fluid-born states of *Penicillium*, and other more or less allied *Mycelia*, are often regarded as Algæ, but they have no affinity with those vegetable productions.

318. One genus of moulds was long considered as peculiarly destructive to living vegetable tissues, and the grape mildew, peach mildew, blanc de rosier, &c., are all attributable to it; but it has already been shown that these supposed species of *Oidium* are not true moulds, but merely states of different species of *Erysiphe*. This is, however, not the case with that class of moulds which belong to the old genus *Botrytis*, or to Corda's genus or subgenus, whichever may be the more correct term, *Peronospora*. These moulds run, by means of their mycelium, amongst the loose tissue of the leaves, and at length protrude fertile branches through the stomates. Tulasne, Caspary, and others, have lately discovered that there is another form of fruit, with far more complicated and larger spores developed at the base of the fronds. The genus *Arto-*

trogus of Montagne very probably includes such forms of fruit. But not only are they destructive to vegetable tissues. Where they penetrate into the intimate organs, as in the case of the silkworm and several other insects, they soon produce death. The muscardine, which is caused by *Botrytis Bassiana*, is capable of being propagated by inoculation, or even without any injury of the tissues the mere act of rubbing a few spores upon the body is sufficient to propagate the disease.

319. Moulds are peculiarly cosmopolites. The species, however, of tropical countries have at present been little studied, but the commoner forms are found over the most distant parts of the globe. The parasitic species of *Botrytis* attain their highest perfection in America, as *Botrytis viticola*. Amongst the black moulds some genera, as *Campsotrichum*, seem exclusively tropical, and fine forms occur in the warmer parts of the United States, but some of these may still turn up in Europe, for one at least of the nobler species of *Septonema*, which are produced in North America, has been found in great perfection in Great Britain. Tropical leaves support a few species besides those mentioned, not, however, in general remarkable for beauty or peculiarity of structure, which do not occur on the leaves of the plants of temperate climates. Amongst the higher forms which present something like an hymenium, as *Stilbum*, a few species affect tropical climes; but if *S. lateritium* and *cinnabarinum*, and one or two less common species, are the ornament of tropical woods, we have, by way of compensation, *S. aurantiacum*, Bab. Till these more obscure and minute Fungi shall have been well worked out, it is impossible to come at any correct estimation of their comparative frequency in the northern and southern hemispheres.

320. Few more beautiful objects are afforded for the microscope, the elegance of which may be best estimated from an inspection of the beautiful figures in Corda's Pracht-Flora. Unfortunately, however, they are rather difficult of observation from the quantity of air which they retain amongst their branches, and their spores are often so loosely attached that the slightest motion, or even the action of the water in which

they are immersed, is sufficient to displace them. With every drawback, however, they still afford much interest with ordinary powers of manipulation.

321. It was stated above, that moulds have a singular facility of adapting themselves to particular circumstances; but not only do changes take place when they are immersed in fluid, but the degree of moisture to which they are exposed has a marked influence upon their development, especially when accompanied by an absence of a free current of air. Under circumstances where the moisture is too great for normal development, two changes take place. In one the mycelium, though at first apparently in its normal condition, soon ceases to grow externally, and forms within a compact cellular mass, which is at length entirely exposed by the gradual disappearing of the floccose threads, forming, in fact, what are commonly called species of the genus *Sclerotium;* in the other case, not only is the mycelium developed, but the fertile threads appear and produce fruit, though under a different form from the normal condition of the plant, transforming, for instance, the genus *Penicillium* into *Coremium. Blastotrichum Confervoides*, Corda, is probably a state of some *Dactylium*, as *Dactylium roseum* (*Trichothecium roseum* of authors). At any rate, it has not the air of a normal plant, and is scarcely separable as a genus, if it were from *Dactylium.*

322. Their distinctive characters depend upon differences of ramification, of carbonization, and of the more or less complicated nature of the spores, which may be either simple or variously septate. There is often a distinct mycelium, called an *Hyphasma*, from which arises a forest of fertile threads; but the floccose creeping mycelium may be reduced to a few cells, and the fertile threads to mere points on the mycelium.

323. Traces of moulds occur occasionally in the cells of fossil woods, or at least threads which are not referrible to any other known phenomena of vegetable organisation; but if the nature of these is doubtful, there is no uncertainty whatever about the occurrence of at least two genera in Amber, a sub-

stance which is well known to belong to formations older than the present condition of the earth. One of these is little different from our common *Penicillium ;* and the other approaches the genus *Corethropis*, Cda.* Traces of other genera also occur, as it is almost certain they would, if moulds were in existence when the pines, which produced the amber, were flourishing, as the resin to which the amber is due, would entrap minute substances floating about in the air, and a few seconds after embalm them, exactly as is the case with gum, which incloses the spores and threads of many species and genera of Fungi, which did not originate within their substance. A fragment, for instance, of the gum of *Cerasus serotina* exhibited the spores of a *Pestalozzia* and *Hypoxylon*, and more would, doubtless, have been found, had the examination been undertaken with the especial view of detecting such matters. Moulds occur abundantly in the apricot or cherry gum of our country.† *Sclerotia* are formed also at the expense of the genus *Mucor*, as was proved by myself and Mr. Hoffman, by causing a *Sclerotium* to germinate in a drop of water, surrounded by a pellicle of air, into which the fertile shoots could protrude. In a single species, *Sporidesmium paradoxum*, Corda observed spiral tissue in the cells which constitute the spores, like that which occurs in the aerial roots of orchids, in anthers, &c., only on a very small scale.

* See Ann. of Nat. Hist., N.S., vol. ii., p. 380. What is figured there as a species of *Streptothrix*, is probably not organic, but due to the motion of bubbles of air in a highly resisting medium.

† Gum tragacanth, which occurs in the form of tendrils and of flakes, is certainly organised, as described and figured by Kützing. Both exhibit large rounded sacs, consisting of several coats, inclosing a cavity containing starch granules. The walls of the sacs are composed of cellulose. Intermixed is a considerable quantity of mycelium. There is not the slightest reason to believe that the production is allied to Fungi. For a fuller account, see Gard. Chron., 1855, under Vegetable Pathology, No. 65, where information will also be found about the occurrence of Fungi in gum.

HYPHOMYCETES.	Fertile threads perfectly free or slightly anastomosing.	1. *Sepedoniei*, Fr.—Fertile threads scarcely distinct from the mycelium. Spores very abundant.
		2. *Mucedines*, Fr.—Fertile threads very distinct, mostly white or coloured. Spores mostly simple, scattered or collected in heads.
		3. *Dematiei*, Fr.—Fertile threads dark, carbonised. Spores often compound and cellular.
	Fertile threads compacted, sometimes replaced by cells.	4. *Stilbacei*, Berk.—Stem or stroma compound. Mass of spores moist, diffluent.
		5. *Isariacei*, Cda.—Stem or stroma compound. Spores dry, volatile.

1. Sepedoniei, *Fr.*

Mycelium predominant. Spores either arising immediately from the mycelium, or from very short fertile threads, sometimes small, but large in the more typical species.

324. These Fungi consist, for the most part, of species in which the spores are highly developed, while the fertile threads are much reduced. The more typical are constantly parasitic on the larger Fungi, as Agarics, *Helvellæ*, and *Pezizæ*, while others affect decaying fruits; the less typical, if all are really allied, occur on various substances. Nothing is more common than to meet with decaying *Boleti* in woods, white with mycelium, but within yellow, from the multitude of globose echinulate spores, which form the greater part of the mass of *Sepedonium mycophilum*. *Helvella leucophæa* is often covered with a rose-coloured bloom, consisting of the large and curious spores of *Mycogone rosea;* a brownish powder, with differently shaped spores, affects a *Peziza*, *Mycogone cervina;* while another, *Sepedonioid* (*Asterophora Pezizæ*), with curious

vesicular spores, calling to remembrance those of *Polycystis*, has been found by Corda on *Peziza labellum*, Bull. The genus *Nyctalis* is so completely metamorphosed externally by the stellate spores of *Asterophora*, that the true nature of the matrix was long overlooked, and the gills or veins which form the hymenium, and which even in specimens infested with the *Asterophora* produce perfect fruit, were supposed to be mere representatives of an hymenium which was always destitute of fructification. But, perhaps, one of the most curious is a species which occurs, not unfrequently, in imported Spanish Chesnuts (Fig. 69, *a*). The white substance of the

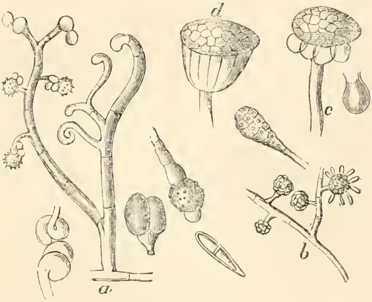

Fig 69.

a. Acrospeira mirabilis, Berk. and Broome, showing the origin of the spores, from the second joint of the spiral fertile threads.

b. Papulæspora sepedonioides, Preuss, showing the young receptacle above, and mature spore below.

c. Ravenelia Indica, Berk. From specimens on *Acacia*, gathered in Behar, by Dr. Hooker.

d. Ravenelia glandulæformis, Berk. and Curt. From S. Carolina, on *Desmodium*. All magnified.

two large cotyledons is completely traversed and altered in texture by the mycelium of the mould, while a few fertile threads are produced in the free space between the cotyledons. If a slice of the diseased cotyledon be placed on damp soil under a bell glass, in two or three days the threads are beautifully developed, and exhibit under the microscope a very curious condition. The tips of the fertile ramuli are curled into a little spiral, which after a time consists of about three articulations. All of these swell, but the second the most, so as to appear to be supported at its base by the other two. The integument becomes slightly rough, and at length strongly granulated, like the spore of a *Genea*, and eventually, in some cases, a second spore is added at the tip. The genus *Zygodesmus* deserves notice, from the peculiar character of its threads. It is possible, indeed, that the species may be conditions of certain Thelephoroid Fungi, but there is no evidence to prove that this is the case. The mycelium, which is always well developed, and creeps extensively, is remarkable for its threads, being frequently very deeply constricted on one side only, so as to look like an imperfect articulation (Fig. 68, *g*). Several species occur in this country, and more than one in South Carolina. I have never seen the mycelium of any well-ascertained Thelephoroid present similar constrictions.

325. Corda considers one or two of the genera of this tribe as parasitic upon other moulds, and in consequence associated them with such Fungi as *Uredo*, an association quite marvellous in the hands of a person who had studied and accurately figured so many Fungi. *Sepedonium mycophilum*, at least, is very widely diffused, and, probably, accompanies the genus *Boletus* everywhere. I have specimens from the Himalayas and the Swan River.

2. MUCEDINES, *Fr.*

Mycelium generally abundant, giving off erect fertile threads, on which the naked, mostly simple, spores are scattered, or collected into little heads, sometimes forming simple or branched moniliform threads. Fruit sometimes double, the second fruit consisting of a large encysted spore of a perithecium containing asci with sporidia, or a sporidiferous cyst.

326. This division comprises a great portion of those productions which are known by the name of moulds, with the exception of the true *Mucors*, which are separated from them rather by structure than by external aspect. The species are, for the most part, pure white, or assume bright and pure tints; a few only, as the common species of *Polyactis*, which are

abundant everywhere, make a slight approach to the brown or cinereous tint, which in its extreme condition indicates the group which follows; a group, even to the external eye, most evidently distinct. As in the former tribe the spores and mycelium were the grand object of development, here the fertile threads, with their fruit-bearing apparatus, have decidedly the pre-eminence. In the genus *Botrytis*, with its various sub-genera, the fertile threads are rarely simple, and the ramifications frequently beautifully regular and highly curious. The spores are often large in proportion, but simple. There is no tendency in the higher species to form any compact head, though the fructifying ramuli are decidedly collected into a distinct truss. In *Penicillium*, the spores are no longer solitary, but necklaces of greater or less length, consisting frequently of very numerous spores, cover the tips of the fertile ramuli. In *Aspergillus* (Fig. 68, *a*, *b*), as in *Penicillium* (Fig. 68, *c*), the reproductive bodies are arranged in threads, but all the fertile threads are crowded into one more or less compact* globose body, so as to form little powder puffs. In other instances, the branches are symmetrically arranged in whorls, sometimes so short as to be mere points on which the spores are seated, offering a most elegant appearance, comparable with that of *Batrachospermum*. In one of these the spores are septate, and in *Dactylium* the articulations are sometimes numerous.

327. Their habits are as various as their external characters. The most inaccessible cavities are not free from their presence, and they occur on living structures, as well as those which are in a state of decay. This true parasitism of some of the species renders them, like other real parasites, capable of producing material injury where they occur in any abundance. Unwilling as the scientific world has been to allow the agency of Fungi in the potato murrain, as regards that, as well as the grape mildew, there are few dissentient voices now, amongst those who understand the subject. The mycelium flourishes in the large intercellular spaces of the leaves, but penetrates also into

* The heads of *Aspergillus*, studded with sporophores tipped with sterigmata (Fig. 68, *b*), are analogues, but not homologues of an hymenium.

the stem and tubers, and at length makes its way either to the external surface or some free cavity, where it fructifies. Difficulties may occasionally arise, but nothing is more sure than that the decay of the leaves and stem is induced entirely by the *Botrytis infestans.* In a damp warm day, the progress of the disease may be watched with ease, and the parasite may be seen spreading rapidly in a circle, converting all in its way into a mass of decay. As regards the tubers, there is often a second enemy, *Fusisporium Solani*, which is equally destructive with the *Botrytis;* and according as the two are separate or combined, different appearances arise. A host of other Fungi, such as *Acrostalagmus cinnabarinus*, soon make their appearance, but these are consequences of the disease, not causes. The *Fusisporium*, it should be observed, puts on different forms according to age and varying condition. *Periola pubescens* is but a form of it, as is also the minute *Dactylium*, which so often grows at the base of the haulm. Sometimes, again, it appears as an obscure *Sporotrichum*, and in some cases produces an extreme degree of hardness, inducing a condition like that of the mummified silkworms (p. 309). Sometimes, on the contrary, it causes rapid and loathsome decay, especially when in company with the *Botrytis.* The *Botrytis* alone in general taints the external cells to the depth of a few lines, but does not produce complete decay. On the contrary, the buds of the tubers remain peculiarly active, and will produce an excellent crop in the ensuing year, and one which is not necessarily diseased.

328. It is quite certain that the species agreeing in habit more or less with these species of *Botrytis* or *Peronospora*, referred to the genus *Oidium*, are not true moulds; but there is one, at least, which has not yet been reduced to any other genus, which forms concentric patches on apples, pears, plums, &c., producing very rapid decay, which deserves notice, viz., *Oidium fructigenum.* The concentric tufts are most remarkable, showing even in these lower Fungi a habit like that of larger and nobler species, which causes the formation of what are called fairy rings. When once the mycelium of this species has gained possession, the decay is very rapid, and this often

takes place while the fruit is still hanging on the branch. It is curious that, as these moulds affect the living tissues of plants, a species not distantly allied should be no less destructive to silkworms, more especially in the larva state, though the pupa is sometimes affected in the cocoons. Where the disease has once made its appearance, nothing will arrest it except the most complete sanatory measures; every part must be well washed with chloride of lime or some other disinfecting substance, which can act effectually on the spores, and a new stock must be procured from an uninfected place. Careful ventilation and extreme cleanliness are undoubtedly great points as regards the prevention of the disease. It has not yet been ascertained whether the Fungus which attacks flies belongs to the same genus. It is probable, however, that what is called *Sporendonema Muscæ*, is merely an incipient state of some more highly organised Fungus.

329. The subject of fermentation has already been mentioned. I must, however, add a few words. Though mycelium is produced in fermenting liquors under particular circumstances, the appearance called ropiness in wine is not due to such a production. It arises from a peculiar state of fermentation, in which lactic acid and mannite are formed, together with a mucilage from which the ropy appearance in question arises.* The forms assumed by the secondary fruit of *Aspergillus glaucus*, *Dactylium roseum*, and the parasitic species of *Botrytis*, have already been noticed.† *Papulæspora* (Fig. 69, *b*), one of the most beautiful of moulds, produces heads of a cellular structure, from the centre of each mesh of which an oblong spore is developed, which was not observed by Preuss, the founder of the genus. The same thing occurs in

* It sometimes happens in France, that dough is so constantly ropy in certain bakehouses, that they become worse than useless. As in the case of Silkworms, just mentioned, the only remedy is to cleanse the walls thoroughly, and wash them with some substance destructive to Fungi.

† It may be added that Caspary finds in *Bot. Umbelliferarum*, instead of the large solitary encysted spore, vesicles filled with minute sporidia (*Sporidangia*).

Rhopalomyces,* a closely allied genus. In this case, however, there is a little spicule which supports the spore.

330. Moulds occur in all parts of the world, where the temperature is sufficient to sustain their growth. They are, perhaps, capable of enduring a greater range of temperature than any other plants, though they could not be produced in temperatures at which some Algæ flourish. Species are seldom collected by travellers, but their specimens often give evident token of having suffered from their growth in the act of drying. *Aspergillus glaucus* is esteemed when occurring in cheese; but with this exception they may be pronounced as mischievous pests, of no practical use to man, except as helping in the work of decomposition, and the preparation of soil for new growths.

3. Dematiei, *Fr.*

Mycelium cellular or floccose, mostly sparing. Fertile threads erect, in general more or less carbonised, and consequently rigid. Spores scattered, whorled, or collected in heads, often large and septate.

331. As the last tribe was distinguished by hyaline threads of various colours, so the present is known by its dark brown, approaching to black, where the tint is deep. It is rare that the tint partakes decidedly of red as in *Œdemium*, the threads of which are of a dark purple brown. Occasionally there is a tint of green, verging almost always on olive. In a few cases only, the threads are hyaline with dark seeds. The distinction,

* Ann. of Nat. Hist., N.S., vol. vii., tab. 5. Several genera occur, in which either single spores or necklaces of spores are produced on such spicules. *Rhinotrichum* is an excellent example, and the same structure obtains in *Stachylidium diffusum*, Fr., though it appears to have been overlooked (Fig. 71, *c*). The fertile branches in their young state are cystiform. Seven spicules, but sometimes a less or greater quantity, soon appear on the surface, which swell into as many new cysts, or sometimes by division into twice that number, covered with a second more numerous set of obtuse processes, each of which supports a spore. I am inclined to think that *Botrytis Bassiana* will eventually prove to be the same thing. Moulds, above all Fungi, require to be traced from an early period to ascertain their history and true structure. I am unable to notice every singular form amongst these productions, as the volume, were I to do so, would extend far beyond its prescribed limits.

though depending principally on colour, is so natural, that a very slight practical knowledge is at once sufficient to detect the species which belong to the section, without much chance of error. The mycelium is seldom much developed, and the fertile threads, which in some species are highly developed, and generally very rigid, are in others reduced almost to nothing. In these cases the spores are larger, and the species approach those of the next order. The spores differ very greatly even in the same genus. In *Helminthosporium*, for instance, if genera are to be founded upon the spores alone, there would be materials for several new names. In a few cases they are simple and small, but in general they are highly developed. In many species they are greatly elongated with numerous septa, while in two or three they are curved into regular spirals. With a few exceptions they grow on exposed wood or on dead vegetable subtances; and in one or two instances, as in *Sporoschisma*, *Helminthosporium* appears as a secondary form of fruit. *Cladosporium herbarum* is perhaps the commonest of all Fungi, and is produced wherever dead vegetable matter, not too highly saturated with water, is exposed to climatic influences, and even animal structures are not safe from its attacks; other species occur in tropical countries. In some cases, as in *Cladotrichum*, the fertile threads are very highly developed, and the articulations of which they are composed assume very curious forms, passing gradually into spores. In *Sporocybe*, as in *Aspergillus*, the fertile cells are crowded into globose heads, crowning the threads and supporting a little puff of spores; and in one of the species the sporophores are swollen, and the spores which they sustain have a deciduous episporium. Little is known of the species which affect other parts of the globe than North America, Europe, and the Mediterranean coasts. *Œdemium* and *Macrosporium* occur in New Zealand, and I have a curious new genus from the Deccan (Fig. 71, *b*). The mildew which attacks linen is often due to *Cladosporium*.

4. STILBACEI, *Berk.*

Mycelium floccose or cellular; stem or receptacle composed of compacted threads or cells, the tips of which produce minute diffluent spores.

332. We have hitherto considered those moulds which possess fertile threads consisting of a single cell, or a single row of articulations. We have, however, shown that *Coremium*, whose stem consists of a compact mass of threads, is merely a concrete *Penicillium*. We come now to those *Hyphomycetes* in which the stem is either essentially compound, whether consisting merely of an agglomeration of threads, or of threads so closely compacted that the filamentous structure is no longer visible, and replaced by cells, still possessing, however, for the most part, a strictly longitudinal direction, though in some cases, as in *Epicoccum*, there is no such disposition. This genus is, however, very anomalous, and is remarkable for its large, often compound and granulated spores, which depart from the normal character of the tribe.*

333. In some cases, as in *Volutella*, the short compact base, which produces a little bed of spores much after the manner of an *Helotium*, except that they are naked instead of being contained in asci, is surrounded by a delicate fringe of hyaline bristles. In *Stilbum* and *Corallodendron*, we have a first approach in perfect Fungi to Hymenomycetous forms, which were, however, shadowed out beforehand by the spurious genus *Tubercularia*, from some forms of which particular species of *Stilbum* are scarcely distinguishable, or still more faintly as an analogue in *Aspergillus*. The species assume brilliant colours, and under the form of *Stilbum lateritium* and *S. cinnabarrinum* are pretty generally distributed in warmer districts. If the stem of such species be reduced to a mere plane or a little pulvinate point, we have at once such genera as *Fusarium*; and if *Ciliciopodium* be compared with *Volutella*, we see at once the propriety of such a notion, for the former is nothing more than a stipitate *Volutella*. Some species of *Stilbum* originate in the inner substance of the bark, bursting ultimately through the external strata. With the exception of *Stilbum* and *Corallodendron*, the genera all

* The mycelium of this genus is often of a deep blood red, causing blood-stains on linen, fruit, and other substances. I have a curious equally abnormal North American genus *Cheiromyces*, Berk. and Curt., which on a cellular base bears digitate spores (Fig. 70, *c*).

belong to temperate climes. Few, however, are known except those which belong to Europe, North Africa, and the United States. A curious *Epicoccum* occurs in New Zealand.

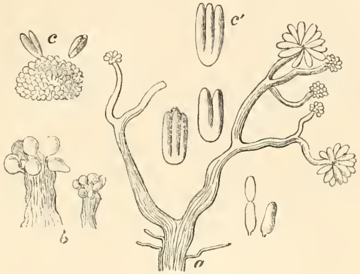

Fig. 70.

a. Chondromyces crocatus, Berk. and Curt., with its spores. Both magnified. From specimens on a decayed gourd from South Carolina.

b. Stigmatella aurantiaca, Berk. and Curt. From specimens on *Sphæria Hibisci*, South Carolina. Magnified.

c. Cheiromyces stellatus, Berk. and Curt.

d. Spores of ditto. Both magnified. From specimens on *Scirpus eriophorus*, sent from Pennsylvania by Dr. Michener.

334. The species of this tribe are mostly of little importance; but one of them, *Fusarium Mori*,* is the pest of silk gardens, destroying the leaves, and thus reducing materially the quantity of food. This genus is, indeed, referred by Montagne to *Fusisporium;* but it seems to me essentially innato-erumpent, and to belong to a higher group than *Fusisporium*, which is one of the *Mucedines*, approximating closely in its diffluent spores to *Stilbacei*. *Fusarium lateritium* is destructive to the young twigs of many trees, but perhaps does not attack them till previously diseased.

* This is *Septoria Mori* of Léveillé, from whom I have specimens. Accounts will be found in Atti del Cong. Sc. di Milano, and by Turpin in Ann. de la Soc. d'Hortic., Paris, vol. 20, p. 329, and vol 22. For these references I am indebted to Dr. Montagne.

5. ISARIEI, *Fr.*

Common receptacle or stem compound. Spores terminating the threads or cells, pulverulent.

335. An approach to these characters was made by *Epicoccum* and *Cheiromyces*, while *Stilbum* already shadowed out some of the clavate *Hymenomycetes.* The last tribe of *Hyphomycetes* approximates, in *Anthina* and *Ceratium*, still more closely to *Hymenomycetes.* It is, in fact, difficult to say in what these genera and *Pterula* differ from them except in being less compact, though *Isaria* is more decidedly mucedinous in its aspect. There is some doubt, however, as to the autonomy of the species which grow on insects, and the same may be said of some other species.

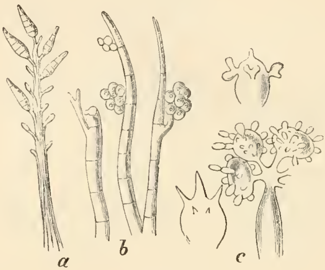

Fig. 71.

a. Podosporium rigidum, Schwein. Magnified. From specimens communicated by Rev. M. A. Curtis, from South Carolina.

b. Pleurobotrya Indica, Berk. Magnified. Gathered at Secunderabad on grass, with *Sphæria Graminis*, by Lieutenant E. S. Berkeley.

c. Stachylidium diffusum, showing the early stage of the fertile head, with seven spicules, of which five only are visible. In the upper figure these spicules are forked, to make two fertile cysts. The third figure represents three fertile cysts covered with obtuse processes, one or two of which bear spores.

336. Several genera which find their proper place in this highest group, and the last, are, in fact, compound forms of organisms which appeared under other tribes. Thus, *Gra-*

phium, Pachnocybe, Podosporium, Sclerographium, &c., are compound *Dematioids; Chondromyces* and *Stigmatella* are compound *Mucedines; Epicoccum*, a compound *Sepedonioid*, &c.

337. One of the most remarkable productions usually assigned to this group is *Ceratium*, which, together with such species as *Isaria Friesii*, is the utmost dignity at which *Hyphomycetes* can arrive, if they are not really Hymenomycetous. Few if any exotic species are known, with the exception of one or two from America, and *Sclerographium rigidum*, which occurs in India. *Podosporium*, however, which appears to be abundantly developed on various species of *Rhus*, is not uncommon in South Carolina (Fig. 71, *a*). It is a compound *Helminthosporium*. *Ceratium* has been found in Ceylon by Mr. Thwaites.

IV. CONIOMYCETES, *Fr.*

Mycelium filamentous or vesicular, often obsolete; fertile threads mostly short, naked or surrounded by a perithecium; spores abundant, often large in proportion to the rest of the plant, though sometimes extremely minute and multitudinous.

338. This grand division is distinguished by the vast predominance of the reproductive bodies over the rest of the plant, if not in size, at least in abundance, and from the ease with which in general they fall from the point of attachment, in consequence of which, as the name implies, they have a dusty appearance, and often soil the fingers of those who handle them. The researches of the Messrs. Tulasne have thrown immense light upon them, in some cases with scarcely any anticipation of the results, in others confirmatory of conjectures before thrown out by authors, like Fries, gifted with that innate tact which divines affinities, though from untoward circumstances it has not the power of proving them. In some cases there is a decided perithecium or peridium, in others there is no approach to such an organ, and it may be observed, that in very nearly allied productions it may be either present or entirely absent.

339. There are three principal groups, each of which is, however, again divisible, and each consisting of numerous

genera. There are, first, the various species of rust and mildew which are parasitic upon living plants, and which may be considered as analogous to the brighter coloured moulds. These, as we shall hereafter see, are separated by peculiar characters from all other Fungi. They were long despised as worthy of little scientific notice, though recognised as the cause of many of the diseases to which our cereals are subject, and are now found to be amongst the most interesting of Fungi, and, in spite of the views of Unger, Turpin, and others, are decidedly as distinct plants as the Phænogamous parasites. Secondly, there are the analogues of the black moulds springing at once from the former division by the curious genus *Xenodochus*, which in general present little interest, except from the form of their spores; and, thirdly, there are the analogues of the *Sphæriæ*, if, indeed, far the greater portion are not mere second forms of fructification of various Sphæriaceous genera.

340. As regards the first, wherever Phænogams occur, they may be found accompanying them, without much restriction as to climate. Cereals are subject to the same parasites wherever they grow. Barley, for instance, on the hot banks of the Soane, is infested as at home with *Ustilago segetum;* and *Puccinia graminum* extends as far south as New Zealand. *Cystopus candidus* occurs both in the extreme north and south, and species grow in Western Thibet, identical with those of Europe. As there are few natural families of plants which are exempt from these parasites, and species are often confined to a particular natural order, different species may be expected to occur in different parts of the world, even taking species with a considerable degree of latitude. The curious genus *Ravenelia* (Fig. 69, *c, d*) has at present been discovered only in warmer districts; but while under one form it infests the different species of *Desmodium* in South Carolina, under another it is abundant on *Abrus* and *Acacia* in Behar. *Cronartium*, which affects the leaves of certain plants in the warmer parts of Europe, in South Carolina and Ohio appears on *Thesium*, *Quercus*, and *Comptonia*. *Peridermium*, which is the pest of pines in Europe, under a different species is no less destructive amongst the Himalayas; and it occurs in

South Carolina on *Ephedra.* While *Ræstelia* affects under one form Pomaceous plants in the northern hemisphere, it reappears at the Cape, attacking the same natural order, and at Ceylon several species occur on very different plants. The curious genus *Sartvellia* (Fig. 72, *a*) has been found only in Surinam. The great requisite for their growth appears to me an atmosphere charged with moisture, while the ground itself is dry; in other words, a damp air without much rain. A constantly dripping country is certainly not favourable to their growth, nor, indeed, to Fungi in general.

341. The species of the second group are no less widely diffused. Little, however, is known of tropical species, but *Sporodesmium Lepraria* accompanies the white spruce as far as its branches are drifted by the waves. Such obscure objects seldom engage the attention of travellers; but New Zealand, at least, is not without them. Dr. Hooker, who neglected nothing which could possibly interest the naturalist, did not gather any species among the Himalayas. On the contrary, they abound in North America, and a species was gathered by Darwin, at the Falkland Islands, on wood, which had, however, been evidently carried there from a distance. As regards the third division, wherever *Sphæriæ* occur, they are their constant attendants, but they are also found apart from that genus. I have, on drifted wood from Wellington Channel, a little species of *Phoma*, identical with one which occurs in England on exposed wooden palings, with indications of another species, both, I think, the growth of the spot where they were found, without a trace of true ascigerous Fungi. In Auckland Island and New Zealand a few species occur, and if little is known of tropical species it may be because such objects are little attended to. The dry and decaying leaves in such countries are not, however, altogether without their species. I have, for instance, a *Pestalozzia* from Cuddapah, and an *Excipula* from Secunderabad.

342. As regards utility little can be said of these Fungi, while, on the contrary, they are the bane of Agriculturists, and sometimes destroy all his hope. The *Sorghum* of hot countries, and the maize of warm districts, are not less surely their

victims, than the oats, and wheat, and barley, and rye, of temperate realms. Though, however, they reduce materially the returns of our cornfields, they do not appear to be directly destructive to life like the *Ergot.* Bunted wheat often forms a very large proportion in flour, and is used more especially for the manufacture of gingerbread, in which the colour is not of much consequence, and the flavour is concealed. In any case, however, it seems to be eaten with impunity. It is said that in reed-beds, where the stems are affected with *Ustilago Typhoides*, the workmen suffer from headache and other bad symptoms, in consequence of inhaling the abundant spores.

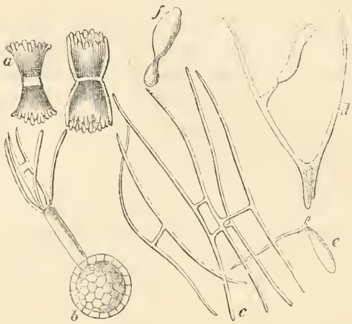

Fig. 72.

a. Sartvellia foveolata, Berk. and Curt. Spores magnified. From a Surinam specimen, from the Schweinitzian collection.

b. Spore of *Tilletia caries*, germinating and producing spores of a second order at the tip of the thread.

c. Spores of the second order seen separately. The two figures are from my Memoir in the Journal of the Hort. Soc. of London, vol. ii., p. 113, 1847.

d. Spore of the third order, arising from germination of spore of second order.

e. Spore of third order germinating.

f. Ditto, producing spore of fourth order. The last three figures are from Tulasne's Memoir in Ann. d. Sc. Nat., 4 sér., vol. ii.

The following table shows the characters and affinities of the principal groups :

CONIOMYCETES.	Parasitic on living plants.		*Cæomacei.*—Spores subglobose, rarely vesicular; simple, or if formed from the articulations of the fertile threads deciduous.
			Pucciniæi.—Spores mostly oblong, septate.
	Growing on dead or dying plants.	Superficial.	*Torulacei.*—Spores more or less moniliform, formed by the rupture of the fertile threads.
		Subcutaneous.	*Phragmotrichiacei.*—Spores arranged in threads.
			Melanconiei.—Perithecium manifestly none.
			Sphæronemei.—Perithecium present, or rudimentary.

1. Cæomacei, *Corda.*

Mycelium traversing the cells of living plants, mostly delicate, giving rise to very short or obsolete fertile threads, terminated by single or concatenated, very rarely vesicular spores. Spores, when germinating, producing a second order of spores, and these occasionally a third, &c. Pycnidia not infrequent.

343. We commence with the true epiphytal parasites which are so abundantly diffused everywhere. The more they are examined, the more complicated do we find their structure. They consist essentially of proportionally large spores, sometimes bursting through their outer integument, either single or forming moniliform threads, arising from a distinct mycelium, which penetrates the tissues of the matrix. It is highly probable that in many species, which never exhibit the spores under the form of necklaces, new spores are formed at the tip of the old sporophores as fast as the old spores fall off, and

hence arises that enormous dusty mass of spores which a single individual is capable of producing. They affect every part of the plant which is sufficiently succulent to admit of the penetration of their mycelium. Not only the leaves and stems, but the flowers themselves, the stamens, anthers, and the inmost recesses of the seed, are in turn affected. There are two principal groups, those in which the spores are disposed indefinitely, and those in which they form distinct sori, covered merely by the cuticle, or contained in a distinct cellular envelope. Those species which infest the sexual apparatus seldom attack the leaves or other organs; but this is not universally the case, for bunt, which seems peculiarly attached to the seed, occurs also upon the stem and leaves; and this is the case, too, with the maize-smut. The principal colour of the smutty Fungi, which constitute the first group, is black or brown, and shades verging on black, but other colours also occur, as red, lilac, and violet. In one fine Himalayan species, on a *Polygonum*, the bractes are expanded, and assume the appearance of inflorescence; but in general the effect is to distort and disfigure the plants on which they grow, sometimes destroying the texture altogether, and sometimes leaving only a few of the harder vascular bundles, as in a species which affects *Gahnia* and other allied plants in India and New Zealand, or, indeed, our own *U. olivacea* on Carices. In *Tilletia* the epispore is remarkable for being reticulated, and while in *Thecaphora* the spores are aggregated or compound, it is possible that in *Polycystis* the external vesicles may be mere growths of the epispore. The germination of several species has been observed, and the first effect is like that of other Fungi; but in many species, as in *Coleosporium* (Fig. 6, *b*), and much more in the species of the next group, the spores germinate at definite points, very much after the fashion of pollen-grains. The sprouting thread is a continuation of the secondary membrane, as is very evident in *Tilletia* (Fig. 72, *b*), from the different character of the external membrane. In fact, in its first stage, it is precisely that of a fern. The spores, however, after all, notwithstanding their analogy, are not immediate means of propagation; they are, in fact, only a sort of prothallus, from which the mycelium grows, producing at the tips or on lateral branchlets bodies of various forms, which are themselves capable of germination, and immediately reproduce the species. These bodies were, I believe, first observed by myself in *Tilletia caries*,* though with nothing more than a suspicion of their real character. I found that whenever the spores of bunt germinated linear or fusiform bodies were generated, which ultimately became joined after the fashion of *Zygnema;* and Mr. Broome and Thwaites, on repeating the experiment at my request, obtained the same result. In my uncertainty as to their real nature, they were described and figured as *Fusisporium inosculans* in the Transactions of the Horticultural Society of London, and in the Encyclopædia of Agriculture, under the word Bunt. Extraneous bodies were then detected in the species of *Podisoma*, but without any clearer notion of their import. Messrs. Tulasne, having had their attention called to the dualism which prevails amongst certain Fungi, ascertained that these growths were general wherever they could obtain germination, and that the bodies produced varied extremely in form, being sometimes perfectly globose, sometimes extremely elongated. In *Podisoma* (Fig. 6, *a*), where a gelatinous element is present, soldering together the elongated stems with their spores into a gelatinous mass, the bodies are oblong and curved, and resemble closely the homologous bodies in *Tremella*. In that genus, too, there is an approach to a prothallus, though, if it be so considered, germination does not take place at the expense of the secondary membrane, but by a simple extension of the outer† membrane or epispore. To add to the resemblance there is some sort of definite arrangement; besides which, in one or two species of *Dacrymyces* the prothallic sporophores are septate, while they are lobed in *Tremella*. In some cases the true fruit is produced only at a late period.

* Journal of Hort. Soc., l. c., p. 112.

† This structure appeared to me so incomprehensible when I published my Memoir on the Hymenium, that I did not venture to figure it. My original sketch is still in existence, and accords precisely with Tulasne's observations in his admirable Memoir.

344. Organisms filled with minute spores exist in several genera, and probably will be discovered hereafter in all. Whether they are only analogues of male organs, or really such in function, remains yet to be proved. The elder Sowerby expressly assigns them this character in his English Fungi, under tab. 410, where they are perhaps figured for the first time.

345. In some instances, as in *Coleosporium*, there are two distinct modes of fructification, apart from the forms induced by germination. In some heaps the moniliform threads are resolved into spores which germinate at definite points (Fig. 6, *b*); in others the sori are more solid, and the threads remain firm, germinating in situ at indefinite points, and producing very much the same combination which exists in *Dacrymyces*.* In *Cystopus* (the white rust of cabbages), the same dualism exists, one form as before, consisting of moniliform threads, while in *Æcidium*, which has also chains of spores, there is but one form of fruit besides the spermatogonia known at present.

346. Many of the most formidable enemies of the farm, as rust, smut, and bunt, arise from Fungi belonging to this tribe. The surest remedy is to steep the seedgrain in some solution, which at once washes off a portion of the spores, and poisons the rest. Many remedies have been proposed, as simple water, salt, lime, sulphate of copper, corrosive sublimate, arsenic. The best, perhaps, is sulphate of soda in solution (Glauber's salts), dried off with quicklime. The lime combines with the sulphur to form sulphate of lime, while caustic soda is set free. Bunt is confined to wheat or nearly so, and in consequence wheat is generally steeped; but smut is so uncommon, or so little feared, that oats and barley are seldom steeped. A bad year, however, like the present, sometimes occurs, which shows that this process is not altogether useless. There was a loss of one third in many barley crops this season. Rust is seldom injurious in this country, but it is formidable on the continent. One form of rust is merely the infant state of wheat mildew, which comes under the following section.

* Tulasne's Memoirs, in the 3rd and 4th Series of the Annales des Sciences Naturelles, must be consulted by those who wish to have full details on these matters, for which I have not room here; and also Bary, Untersuchungen über die Brandpilze, Berlin, 1853.

347. Besides the Ustilaginous species, there are others which grow for the most part in definite tufts, and which constitute the old genus *Uredo.* Some of these are brown, but the greater part are of a bright yellow, inclining often to orange, while one genus, *Cystopus*, has spores of a pure white. It is amongst these that the larger spores occur, which, though often abundant, are scarcely ever so much so as to make them disagreeable objects like the dusty Ustilagos.

348. Most of the genera have merely the cuticle as a covering; but in *Æcidium* there is a distinct peridium, consisting of a single layer of closely packed cells, which, when the cuticle of the plant bursts, protrudes, and either forms an irregular sac, or bursts by means of radiating fissures, the laciniæ curling back and presenting an elegant object for the microscope. In some cases they are extremely numerous and linear, in others they adhere above, allowing the spores to pass between them, as through the wires of a cage. In most cases the matrix is only very slightly affected. The mycelium, indeed, penetrates into and between the tissues, partially exhausting them or oxydizing the chlorophyl, so that the leaves on the parts opposed to the pustules exhibit autumnal tints. Sometimes, however, the effect is most extraordinary. The *Æcidium* of the Elder distorts and curls the stems till they appear to be something totally different from the original plant, while in other cases large gouty swellings appear, or the inflorescence is entirely suppressed, and the peduncles alone remain filled with reproductive matter. Those species of *Cissus* which are infested with smut, have thus given rise to a spurious Phænogamous genus in *Relliquiæ Haenkeanæ.* In other instances, the change is considerable, though the original outline is more perfectly preserved, as in those *Æcidia* which attack the leaves of different species of *Anemone.* In such instances the leaves, which will be eventually covered with the Fungus, show that they are impregnated with its mycelium as soon as they make their appearance. In some cases, as in bunt, this is evident from the peculiar glaucous aspect assumed by the infected stems.

349. One genus, *Ravenelia* (Fig. 69, *c*, *d*), still requires to be

noticed, as it is one of the most curious in the group. The spore in this case is of considerable size, and evidently reticulated, and below it, either free or in contact with the stem, is a circle of colourless bags, foreshadowing a more complicated system of articulation than even in the following group. The germination of these has not at present been observed. It is probable that the number of threads to which the spores give rise is considerable.

2. PUCCINIÆI, *Berk.*

Mycelium traversing the cells of living plants, mostly delicate, giving rise to short or elongated fertile threads, terminated by more or less elongated septate spores. Spores, when germinating, producing a second order of spores.

350. The species of this group differ from the last merely in the circumstance of their spores or prothallus being more complicated. The circumstances of germination, growth, &c., are precisely the same, and require but little addition. They do not in general distort the matrix so much, and are remarkable for their rich golden brown hues, which in some is exaggerated into deep bay. In some cases, as in a beautiful species from South Carolina, a granulated episperm separates from the prothallus; and in the singular genus *Sartvellia* (Fig. 72, *a*), either division is crowned with a large number of short processes. One circumstance is worthy of note, that more than one species of *Puccinia* sometimes occurs in the same pustule; but not only is this the case; *Uredines* and *Pucciniæ* very commonly coexist. In *Uredo linearis*, the so-called spores are merely the early stage of *Puccinia graminis*. But not only are these species ascribed to *Uredo*, though not really autonomous, but many species of *Puccinia* are accompanied by bodies simulating exactly those of *Uredo*, though, in fact, only secondary forms of fruit. This is most remarkable in the genera *Aregma* and *Xenodochus* (Fig. 73, *a*, *b*), which are not to be regarded as doubly parasitic, but as species presenting twofold fruit in one pustule. Such considerations will eventually reduce the species of *Uredo* to a great extent; but we are not to suppose that there are therefore no autonomous species of that genus. Length of time and multiplied observa-

tions can alone clear up all such difficulties, and restrict genera within just limits. The prothallus of *Puccinia* sometimes exhibits several layers in the epispore (Fig. 73, *e*), a circumstance which is not common amongst Fungi. *Podisoma* and

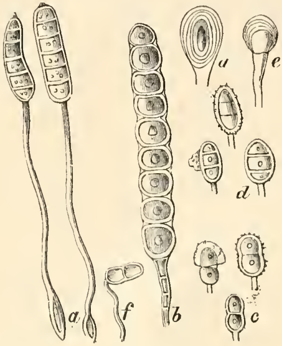

Fig. 73.

a. Aregma speciosum, Fr. From South Carolina.
b. Xenodochus paradoxus.
c. Puccinia Amorphæ, Curtis, showing the deciduous outer coat. From South Carolina.
d. Triphragmium deglubens, Berk. and Curt. From Texas, with its deciduous coat.
e. Young spores of an unknown *Puccinia*. From South Carolina, showing the numerous layers in the outer coat.
f. Puccinia lateripes, Berk. and Ravenel, on *Ruellia*. South Carolina.
All more or less magnified.

Gymnosporangium are merely *Pucciniæ* with greatly elongated stems, and the addition of a gelatinous element. One singularity about them is, that the disc from which they spring produces a new crop year after year, till the mother plant is exhausted and dies; while in *P. macropus* the matrix swells into a large globular mass, having the appearance of some Echinus divested of its columnar spines. It is probable that in this case and in *Cyttaria*, which has similar habits, the mycelium creeps through the bark so as to make its appearance again in a new spot at some distance from the original position; as Dr. Brown suspects may be the case with some of those parasitic plants which appear from the bark at once, under the guise of large flowers, without any save rudimentary foliage. In neither case, however, is the position perfectly demonstrable, though highly probable. *Triphragmium* is distinguished from *Puccinia* by the addition of a vertical septum as well as the horizontal one. In *Aregma* the cells are greatly multiplied, and the stem is curiously swollen at the base; while in *Xenodochus* the prothallus is extended so much as to have the appearance of a *Torula*, and thus to depart from the typical character. The germination of this latter genus has not been observed; but it will, in all probability, prove similar to that of its allies.

351. *Puccinia graminis* has long been known as the cause of mildew in wheat, a plague for which no remedy has hitherto been found. Since the discovery that the bodies which were supposed by Sir J. Banks to be capsules, are merely anticipations of the true spores, and that germination does not take place as soon as the prothallus is ripe, it is probable that the remedy suggested some years since by Mr. Tycho Wing, the eminent land-agent of the Bedford Level Estates, viz., to allow no reeds or loose grass to remain in the ditches, but to clear everything away, and to consume it at once, is one of the most effectual. As the species which attacks reeds and grass is to all appearance the same with that of the wheat, the disease may be propagated in the spring from such outliers. For the same reason, it is desirable that the stubble should not be left on the land too long, and, indeed, long mowing must be better than reaping. With the exception of a few *Pucciniæ*, the Fungi of this group are natives of temperate regions. *Aregma* is rare in America, but there is one most beautiful species which may vie with any of ours (Fig. 73, *a*), as may the *Podisoma macropus* with our native species. *Acalyptospora*, Desm., is perfectly free, but I am not certain of the affinities of the genus, nor, indeed, whether it is a true Fungus.

3. TORULACEI, *Corda.*

Mycelium filamentous or cellular, sparingly produced; fertile threads bearing erect moniliform chains of spores; spores formed by the deciduous joints, simple or articulate.

352. The black weather-stains on wooden structures, and the velvety or sometimes bristly spots which so often meet the inquirer's eyes on stems of herbaceous plants, &c., are in great part attributable to this group. They are Fungi in which

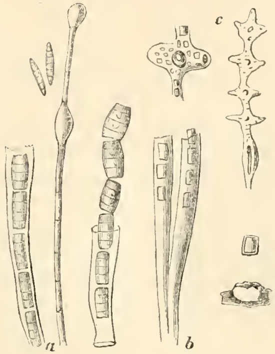

Fig. 74.

a. Sporoschisma mirabile, Berk. and Br. Threads bursting above and discharging the triseptate spores, with one of the Helminthosporoid threads and spores (*Helminth. bacilliforme,* Mont.), which always accompany them. Magnified.

b. Asciform threads of *Bloxamia truncata,* Berk. and Br., with a single plant at the base surrounded by a delicate envelope and a single spore above.

c. Phragmotrichum Chailletii, thread and joint. From Massachusetts. Magnified.

there is no trace of any common perithecium, nor even of an investing cuticle; the fertile threads are reduced in general to a minimum, and the fruit composes far the greater part of the plant. In many cases this fruit is simple, whether growing singly or arranged in necklaces; in many, again, whether single or concatenate, there are many septa. Some of these productions, such as the lower *Sporidesmia* and *Coniothecium*, are scarcely autonomous, but it has not yet been discovered to what true species they belong. The constant union of *Sporoschisma* and an *Helminthosporium*, seems to point to dualism (Fig. 74, *a*). In this case the endochromes of the threads adhere together in little packets, and escape from their ruptured ends exactly as in some species of *Calothrix* and other allied Algæ. In two or three genera the spores form more or less perfect spirals. *Spilocæa* is the only one which affects living tissues. It is common on apples, forming the black specks which are occasionally multiplied so much as to make them unsaleable. This genus is, however, a mere degeneration of *Cladosporium*, a genus which has several truly parasitic forms. Few of the species have at present occurred in tropical realms; but this is perhaps less from their actual absence than from their not attracting notice. *Echinobotrys* has been sent me by Lieut. Hobson from Bombay; and as it seems to occur on the threads of several Fungi, I am inclined to think that it is rather of the nature of pycnidia, a secondary fruit, than an autonomous plant. Though I have often found it in England, it has never been in such a state as to afford any satisfactory solution of its real character. One of the most obscure species, *Sporidesmium Lepraria*, gave occasion to some observations of considerable interest at the time, as making it probable that Sir John Franklin's party, after leaving Beechy Island, had gone in the direction of Wellington Channel. The details will be found in a report to the Admiralty, on some fragments of wood picked up in that direction, which is printed in Sutherland's Journal.* The course actually pursued before the loss of the ships is, however, still as obscure as ever, and the inferences there derived may still be true.

4. PHRAGMOTRICHIACEI, *Corda*.

Subcutaneous. Perithecium irregular or obsolete. Spores generally cellular or septate, in moniliform threads.

353. We have here the first indication of a perithecium,

* Journal of a Voyage in Baffin's Bay in 1850, 1851, Hook. Journ., vol. v., p. 33.

except so far as it was shadowed out in *Æcidium* and *Rœstelia.* In *Cystotricha* we have a *Torula* growing from a sort of hymenium, and in *Bloxamia* we have a *Sporoschisma* (both on a reduced scale) in the same position. In *Phragmotrichum* (Fig. 74, *c*), the spores are very singular in form. *Seiridium* may be compared with *Alternaria. Pilidium* and *Excipula* are better, perhaps, placed in the next group. *Bloxamia* (Fig. 74, *b*) is curious, because the disc consists of close-packed threads containing quadrate spores. When the lid of the perithecium falls it carries with it the tips of these threads, the contents of which are then exposed. The evident relation between *Bloxamia* and *Sporochisma,* as well as many peculiarities about the plant, forbid the junction of the former with *Ascomycetes,* to which it bears a close analogy. The plant is, however, very minute, and requires careful examination. It should be observed that there are several genera of precisely similar habit, and closely agreeing in external character, so as to make the determination in some measure doubtful without actual microscopic inspection. How far these may be distinct autonomous plants, for one of them at least, *Xylographa parallela,* bears perfect asci, must be left to future observation. *Myxormia* is remarkable for its exposed disc. The perithecium or excipulum, for perhaps it is never closed, is here composed of erect, laterally confluent threads whose tips are free and obtuse. The geographical limits of the genera are at present unknown. They have hitherto been found only in Europe and the United States.

5. MELANCONIEI, *Corda.*

Mycelium or stroma forming a distinct cushion, from which the fertile threads or sporophores spring; spores various. Perithecium wanting.

354. This division is distinguished by its abundant spores, frequently oozing out in vast quantities from the receptacle, for there is no perithecium, and either forming black stains round the orifice, or a distinct globule or tendril, according to the quantity of mucilage which accompanies them. The spores vary very greatly in appearance and character. They may exhibit bright tints of pure red and yellow, or may be

almost jet-black, with all sorts of intermediate shades. In some they are extremely minute and often curved, in others they are large and variously septate, while in *Myriocephalum* they are seated in tufts at the tips of long filaments, as if they were so many miniature *Penicillia.* In *Asterosporium* they are curiously joined at the base so as to form little stars or caltrops.

355. Various, however, as their characters are, it is quite certain that a larger number of the supposed species is not autonomous. Mr. Broome and myself found *Sphæria inquinans* and *Stilbospora macrospora* produced from opposite sides of the same cellular matrix, and the connection between other *Sphæriæ* and such genera as *Myriocephalum* is equally clear. It does not, however, follow that there are no autonomous species. They are, with scarcely an exception, productions of the northern hemisphere; and some of them, as *Myriocephalum*, descend as far as the shores of the Mediterranean. At present not one of them has turned up in New Zealand, and I do not recollect that I have a single antarctic species in my herbarium. The Fungi, however, of New Zealand have not been half explored, and as the same rule holds good amongst Cryptogams as Phænogams, that genera are more abundant in proportion than species, many gaps may ultimately be filled up which will extend the geographical limits of some groups of Fungi, at present supposed to be confined to the northern hemisphere. *Bactridium* approaches far nearer to the Mucedinous type than the rest, but is placed here on account of its resemblance in point of structure, though not in colour, to *Coryneum.* *Nemaspora* oscillates between this and the following, as does *Discella*, which makes a further approach towards a perithecium.

6. Sphæronemei, *Corda.*

Perithecium distinct, free or erumpent; spores basal or parietal, simple or septate, sometimes oozing out by the contraction of the perithecial walls.

356. We now come to a very large and in general unsatisfactory group of productions, the abomination of all mycologists, especially of those who are unfortunate enough

to have thousands of such matters submitted to them in the course of the year with the expectation that a distinct name shall be assigned to every one, however obscure and devoid of interest. It was remarked by Fries, with his usual acuteness, that imperfect mycologists too often pass over the objects which surround them of real interest, while they collect and number every dead twig or stipule that has the most microscopic black speck. The structure of the greater part of them is much the same : an obscurely developed perithecium, minute sporophores, and microscopic spores, often differing in nothing more than microscopic dimensions. Now, even if these were uniform in size, which is very far from being the case, microscopic measurement is very uncertain when bodies less than the five thousandth part of an inch are in question, and some of them are at least three times as small. No accuracy, indeed, can be obtained without the best instruments, and very skilful manipulation. But besides this, it is quite certain that a large portion of the so-called species of *Phoma*, *Leptostroma*, *Diplodia*, *Hendersonia*, *Cytispora*, *Septoria*, &c., are mere cases of dualism, and the same may, without much chance of error, be predicated of those cases, as *Dilophosporium*, *Neottiosporium*, and *Pestalozzia*, where the objects are of some interest on account of their curious appendages. All, indeed, are interesting so far as ascertained dualism is concerned, or as far as there may be a prospect of showing that they are the spermatogonia or pycnidia of ascophorous species. One of the most interesting cases, perhaps, which has occurred is that of the production from the same hymenial surface of distinct asci and the double spores of *Diplodia* (Fig. 60, *c*). The so-called species are as multitudinous as the *Uredines ;* and even supposing them to be autonomous, there is no doubt that they ought to be very greatly reduced ; but the fact is, that the determination of a very large portion of them is altogether empiric. No man would spend a life in the study of objects of so little interest ; and if every *Sphæria* has its pycnidia, it is at once obvious that there must be more than a thousand productions of the kind, which have a claim to distinct individuality, so far as the *Sphæronemei* alone are concerned. As regards geographical distribution they are found wherever true *Sphæriæ* exist. We have them, for instance, in the extreme limits of the arctic and antarctic vegetation, and in every intermediate temperate region ; nor are they wanting in tropical climes. I have, for example, *Pestalozzia* from the Deccan. Such productions are, however, so seldom gathered by travellers that we really are scarcely in a condition to form a proper estimate. In New Zealand several species have turned up. They swarm in South and North Carolina. *Aschersonia* appears to be peculiarly tropical, occurring in Southern India, Ceylon, St. Domingo, Tahiti, &c.; but it has quite the air of being an altered form of *Hypocrea*. The same species of *Phoma* appears on the bleached wood of the extreme Arctic regions, and on exposed palings in Northamptonshire. Some of the species, though small, are extremely destructive to vegetation, especially species of *Septoria*, which sometimes occur on leaves or fruit in such abundance as to exhaust their vitality. The greater part, however, grow only on dead or dying organic productions, and therefore merely act a part in reducing effete organisms to a condition in which they may again take their part in the cycle of production and reproduction.

V. Gasteromycetes, *Fr.*

Mycelium gelatinous, floccose, or cellular, giving rise to a distinct often stipitate peridium, consisting of one or more coats, inclosing free or compacted threads or laminæ, from which the spores spring, and in the most highly organised genera a distinct though convolute hymenium. Spores naked, or very rarely surrounded by a cyst, but then springing from the tip of the fertile thread.

GASTEROMYCETES.

Coniospermous.

Myxogastres.—Whole plant at first gelatinous. Peridium containing at length a dusty mass of threads and spores.

Trichogastres.—Plant at first cellular. Hymenium drying up and leaving a dusty mass of threads and spores.

Hymenomycetous.

Nidulariacei.—Peridium inclosing one or more distinct free or stipitate sporangia, which contain a mass of cells, of which the central ones produce spores or sporophores.

Phalloidei.—Hymenium passing into a diffluent mass.

Hypogæi.—Subterraneous; naked, or invested with a confluent or very rarely a distinct peridium.

Podaxinei.—Stipitate, subclavæform; hymenium convolute, inclosed in a volvalike peridium, withering or entirely drying up so as to form a dusty mass.

357. We have now arrived at one of the most important divisions of Fungi, containing many of the most curious and beautiful productions of the order, though not equal in dignity to the *Hymenomycetes.* As the name implies, the fructification is essentially produced within the surrounding tissues, and it is only in the most highly organised that an approach is made to the Hymenomycetous type. A large portion are remarkable for the drying up of the hymenial tissues to such an extent, that the cavity contains a dusty mass of spores mixed more or less with threads, or the shrivelled remains of the constituent tissues, but this is not without exceptions; in the *Nidulariacei,* the hymenial cells are always closely compacted, and in the *Phalloidei* they are mixed with or resolved into mucilage, so as to drip down from the hymenium. Some, again, are of a fleshy consistence when young; while others, in an early stage of growth, exhibit little more than an apparently inorganised mass of pulpy matter. In one or two genera, the cells of particular parts connected with the spores exhibit beautiful spiral threads, which in *Trichia* are frequently branched. In *Batarrea* (Fig. 5, *a, b*), the spiral is loose and easily distinguished; while, on the contrary, in

Podaxon (Fig. 5, *c*) it is peculiarly close. In that genus, the outer wall frequently splits in a spiral direction.

358. This order contains a few articles of food, though not in general of much importance. The gelatinous volva of *Ileodictyon* is eaten in New Zealand, but it must be a very unpleasant kind of food; and the same part of *Lysurus Mokusin* is eaten by the Chinese. A species of *Secotium*, in Australia, is said to be extremely good and delicate; but probably the best of all is *Lycoperdon giganteum*, which, when young, is considered excellent by all who have partaken of it. A species of *Lycoperdon* is commonly sold in the bazaars at Secunderabad, but I have not yet received specimens. *Bovista plumbea* is sometimes eaten in that condition, and I have myself partaken of it; but I am, perhaps, not sufficient of an adventurer in such viands to pronounce it good, where anything else can be procured; a verdict which I should be inclined to give of some other esculent Fungi which are highly lauded. One group consists entirely of truffle-like species, mostly of a small size, and a heavy disagreeable smell. *Melanogaster variegatus* is, however, often sold in the market at Bath; but it must be very inferior to the common truffle. The contents of several species of puff-balls, but more especially of *Lycoperdon giganteum*, are used to stanch blood; and it has lately been discovered that the fumes of the same substance, when ignited like tinder, have a property somewhat resembling that of chloroform, and may be used, therefore, to stupify bees, or even in other cases where æther or other anæsthetics are employed. *Racodium cellare* has the same property, but soils the honeycombs.

359. As regards distribution, *Gasteromycetes* are found in all quarters of the globe. They are abundant in some parts of the tropics, and such genera as *Podaxon* and *Secotium* are scarcely found; except where the temperature is tolerably high, or the climate equable. *Secotium* occurs in a miserable form in the south of France, but under one of great beauty in New Zealand. One or two species of *Gyrophragmium* occur in the Russian steppes, or in the south of Europe, and *Podaxon* is found in Africa; while *Montagnites*, in addition

to these localities, is found slightly altered in Texas. *Mitremyces* has not occurred at present in Europe; but it is found far beyond its former limits, as in Khassya, Java, and Australia. The curious genus *Husseia* has hitherto been found only in Ceylon, and *Broomeia* only at the Cape. With these and one or two other exceptions, the genera have a wide distribution, and perhaps further researches would much diminish those cases which at present seem isolated. *Nidularia*, though ascending far to the north, has many representatives in warmer climates, and several species occur under a tropical sun. *Trichamphora*, which was originally found in Java, has lately been received from Tahiti, and it has also occurred in South Carolina. *Trichocotyle* (Corda), formerly *Trichocoma*, was also first found in Java; but I have it both from the Sikkim Himalayas and South Carolina.

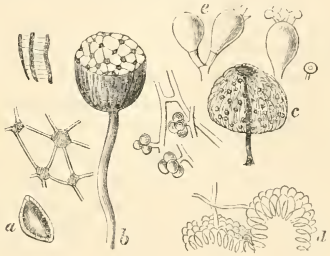

Fig. 75.

a. Spore of *Trichamphora Pezizoides*, Jungh. From Tahiti.
b. *Cribraria intricata*, Schrad, with a portion of the network and the lower half of the peridium. From South Carolina.
c. *Enerthenema elegans*, Bowman, with the bunches of spores.
d. Portion of hymenium of *Lycoperdon cœlatum*, with the threads.
e. Sporophores and spores of *Lycoperdon giganteum*.
All more or less magnified.

1. Myxogastres, *Fr.*

Whole plant at first gelatinous. Mycelium often veinlike, forming reticulated or anastomosing strata, but sometimes diffuse, giving rise to sessile or stipitate, free or confluent peridia, consisting of one or more membranes, inclosing, when mature, a dry mass of threads or plates, and spores; at length often bursting. Threads of various structure, sometimes containing one or more spirals.

360. This is, perhaps, one of the most remarkable groups of Fungi, and at present one on which we have the least information, as regards the history of the development from the spore to the perfect plant. In their early stage they consist of a pulpy or creamlike mass, collected in distinct globules, or creeping over the matrix in the form of branched anastomosing veins, often of bright and pure tints, or occasionally void of any definite form or order, which produces sometimes one, sometimes many peridia. In this stage the tissues are so delicate that they exhibit no structure, and if hardened by alcohol they give no further information; just, however, as these Fungi are passing from the pulpy to the dry pulverulent state, which all assume in their second stage of growth, there are slight indications of structure, and in one or two instances the mode of attachment of the spores has been discovered, viz., to short threads, singly or in groups, and sometimes, as in *Badhamia* and *Enerthenema*, surrounded by a cyst.

361. From their great fragility when fully grown, and the free dispersion of the dustlike spores, they are with difficulty preserved in the herbarium; but no Fungi afford more elegance of form, or singularity of structure, according to the nature of the peridium, flocci, and the disposition of the spores, which are their three main elements. These parts may be taken in order with a view to the elucidation of the group.

362. The peridium sometimes consists of a mere membrane, with a very slight indication of cells, if any. Sometimes it is studded with granules, or has granules imbedded in its substance, and sometimes it is traversed by branched or reticulated veins, more or less distinct, according to circumstances, from the rest of the peridium. In some cases there is no stem whatever, and the peridium, which may be either single or double, splits irregularly, or bursts into radiating fragments, which present a pretty flowerlike appearance, especially in those cases where there is a distinct columella at the base of

the cavity. Beauty of form is, moreover, often combined with exquisite colouring, which is sometimes brilliantly metallic, exhibiting tints of steel, gold, copper, or silver, and sometimes vying with precious stones.* In a multitude of species there is a well-defined stem, which may either spring directly from the matrix, or from a membranous expansion, the remains of that part of the original pulpy matter which was not developed into peridia. In these cases, the rupture sometimes takes place with a regular horizontal fissure, so as to present the appearance of a little cup with a convex or flat lid, often of a chalky aspect. Sometimes the membranous portion of the peridium separates half way down, as in *Cribraria* (Fig. 75, *b*), the upper portion consisting of curiously branched veins, through the interstices of which the spores escape; and sometimes, as in *Dictydium*, the membranous coat vanishes through the whole course of the peridium, leaving behind a variously reticulated balloon, which is often umbilicated above or below, so as to present an exquisite object under a low magnifier. The peridium consists of one or two membranes. In *Physarum* there is but one, which is, for the most part perfectly smooth, and often showing the most brilliant prismatic or metallic tints; in *Diderma*, they are perfectly distinct and separate, more or less completely, from each other; while in *Didymium*, the outer coat assumes various forms, being floccose, furfuraceous, or squamose.

363. The flocci again exhibit as various differences as the other elements. In some cases they are equal in length throughout, variously branched, sometimes attached to the walls, sometimes to the columella. In *Arcyria*, they form a beautiful elastic network, which is greatly elongated on the rupture of the upper part of the peridium. In some cases the threads are in parts, especially where they branch, much flattened, and form triangular or multangular expansions, with occasionally a central cavity resembling an intercellular space; a structure which also obtains in the veins which traverse

* Very thin dry membranes in the animal kingdom sometimes exhibit such tints. I have a pear-leaf studded with the eggs of some moth, the substratum of which is beautifully prismatic.

22

the peridium in some species of *Cribraria*. In *Reticularia*, this flattening and expansion of the threads are carried to the greatest extent. When the spores are all dispersed, the processes which remain attached to the base look like a number of erect lacerated chaffy scales, resembling those with which the pilei of some *Hymenomycetes* are clothed, though not so rigid. In *Angioridium* they appear like thin shapeless chalky shreds, by contrast with the dark fruit with which they are intermixed. In *Trichia*, the threads, which are either simple or branched, contain one or more spirals, a structure first noticed by Schmidel, and more fully demonstrated by Hedwig the younger, and in modern times by Corda. Some doubt has lately been expressed on this subject; but the best microscopes certainly show one or more internal spiral threads. In some instances, the external membrane is studded with asperities, to which, perhaps, the spores were originally attached, but this is uncertain. In *Arcyria*, which comes so near to *Trichia*, there are peculiar asperities of a somewhat similar nature, confined to one side of the threads. In some cases, very probably, the outer membrane itself may have a spiral structure, as will be noticed hereafter in *Podaxon*.

364. The spores do not differ very greatly in most of the genera; they are, however, occasionally echinulate, as in *Badhamia*, or reticulate, as in *Trichamphora* (Fig. 75, *a*). They assume a great variety of colours, generally more or less tinged with red, and sometimes of a pure red or scarlet. They are, for the most part, undoubtedly attached to the threads; but in two genera, *Enerthenema* and *Badhamia*, they form definite groups, surrounded by a common cyst. Sometimes the spores, under such circumstances, are uniform; but in most instances the exposed side exhibits asperities which do not exist towards the centre of the group, and sometimes the external spores are grouped round a larger central spore. Corda has shown a definite arrangement of the spores in one genus; and the fact that the spores of *Hymenangium*, though essentially borne on sporophores, are sometimes surrounded by a sac, forbids our attributing so much consequence

to the structure as to remove closely allied species into different groups, on account of this anomalous appearance. Perhaps the establishment of the Physomycetous group amongst the simpler Fungi might be objected to on account of the perfect analogy of such genera as *Acrostalagmus*, and the disposition of the fruit in *Badhamia;* but it rests on other considerations, and the question, perhaps, is not so much whether *Physomycetes* be a natural group, as whether *Acrostalagmus*, with its dualism of vesicles and naked spores, belong really to the group, and not to *Hyphomycetes*.

365. We have hitherto spoken of those cases only where the peridia are perfectly distinct, but there are genera, as *Æthalium*, *Spumaria*, and *Licea*, where the mass is more or less confluent. In *Licea*, indeed, the tips of the peridia are distinct, while in the other genera the whole mass is so confused that the peridia look like mere membranes amongst the spores. We know of no use to which these plants can be applied; a few only are abundant and large enough to make their use possible. *Æthalium septicum* is the pest of hothouses; and other species, especially a *Licea*, have increased occasionally so much in cucumber and melon frames, as to interfere seriously with their culture. Dr. Wollaston found the spores of *Reticularia maxima* to yield a phosphoric glass, and, from their great uniformity of size, suggested that they might be employed in minute measurements. It is, however, doubtful whether the identity of size is sufficiently accurate to enable the observer to avoid error. These plants are found in various forms in most parts of the globe; they descend as low as New Zealand, and occur in high northern latitudes; while the tropics afford many beautiful species, which, however, have not been studied so much as they deserve, because of the difficulty of preserving them for the herbarium. *Arcyria punicea* and *Stemonitis fusca* are found in very hot and in very cold climates. *Æthalium septicum* is produced equally in woods, and in the hot damp air of the stove, a situation in which some other species thrive. One peculiarity is their indifference as to the matrix on which they grow. The same species may occur on plants of the most distant natural affinities, and on

other matrices. One species was observed by Schweinitz to be developed on iron which had been heated in the forge only a few hours before. Mr. McIvor found one on a leaden tank; and another was found by Mr. James Sowerby in the outer gallery of St. Paul's on cinders. The fact appears to be, that, like Algæ, they derive their nutriment in general from the surrounding medium, and not from the matrix on which they grow. *Reticularia umbrina* sometimes grows on the hardest wood, where it can derive no nourishment from the matrix.

2. TRICHOGASTRES, *Fr.*

Substance at first carnose; peridium simple or compound, varying greatly in thickness, the outer coat sometimes bursting like a volva, inclosing a convolute hymenium, which at length vanishes, leaving a mass of threads and dusty spores.

366. Though in a state of maturity there is such a close resemblance between this and the foregoing tribe, in infancy few productions can be more different. While the *Myxogastres* present a pulpy mass, with scarcely any traces of organisation, we have here almost the first intimation of a regular hymenium, except so far as it was shadowed out in *Isariacei* or *Stilbacei;* only, instead of being spread over a definite surface, by the intricate folding and introsusception as it were of the trama or substance from the cells of which the hymenium springs, it occupies the surface of innumerable sinuous folds and cavities, all closely compacted into a crumb-like mass, within one or more external coats.

367. Within a short compass, few classes present more curious modifications than the genera of which this tribe is composed. On the confines of *Myxogastres,* we have the little group consisting of *Coniocybe, Byssophyton,* and a new genus, to which I have given the name of *Emericella.* These are, in habit, more or less Lichenose, but differ from *Calicium* and allied genera, in the total absence of asci. *Emericella,* of which a figure is subjoined, consists of little oblong or clavate masses, varying in colour from yellow to green and grey. A vertical section shows a little peridium above, filled with threads and globose purplish spores, remarkable for a border of long spines, all situated in the same plane. The peridium is supported by

Fig. 76.

Emericella variecolor, Berk. and Br.

a. Vertical section of peridium and stem.

b. Gonidioid cells on the threads, with which the lower part of the stem is clothed.

c. Gonidioid cells in various conditions.

d. Tissue of centre of stem.

e. Spores with processes all situated in the same plane.

All more or less magnified.

a spongy central column, giving off threads which are terminated by large globose bodies resembling closely the gonidia of Lichens, but growing very much like the *Palmella*, figured at p. 118. Dr. Montagne has observed these bodies to become blue with iodine, but this is not confirmed by myself or Mr. Broome. I have, in fact, tried various preparations of iodine, and the addition of sulphuric acid has given no blue tinge. The general colour of the plant does not arise from these bodies so much as from the fine threads on which they grow. Increase in many cases certainly takes place, exactly as in the *Palmella*, by the division of the central nucleus, and in one instance I have observed two of them to be confluent.*

368. In more normal species, we have either a single peridium, with traces of a second in various granules, spines, or stellate

* This very curious Fungus was gathered by my son, Lieut. Emeric Streatfeild Berkeley, in his garden, at Bowenpilly, near Secunderabad. I have named it *Emericella variecolor*, and it is certainly one of the most curious that has ever come under my notice.

appendages, or we have a second separating readily from the other, as in *Bovista.* In these cases there may either be a rudiment of a stem, or the peridium may be perfectly sessile. The stem, in fact, is nothing more than a continuation of the barren cells which underlie the hymenial mass, and either pass into it directly, or are separated by a more or less definite stratum of cells, as in *Lycoperdon cœlatum.* The hymenial mass, again, may either be simple or compound, divided, that is, as in *Polysaccum,* into numerous secondary peridia, or merely traversed, as in *Scleroderma,* by veins of a different aspect, calling to mind the peridia of *Æthalium,* and other compound *Myxogastres.* Though these plants exhibit a fleshy texture when immature, or rather a crumby aspect, like that of the inside of a loaf, as they advance to maturity, the whole aspect is changed. The hymenial walls dry up, the threads with which the cavities were traversed remain, and the whole forms a mass of dust and filaments, staining and polluting everything with which it comes in contact. It is rare that there are definite characters about the flocci; but in *Mycenastrum* the threads are far more highly developed than usual, and present upon their branches spinelike processes. The spores in the first instance are seated on the tips of quaternate spicules, which grow at the apices of the component cells of the hymenium or sporophores, a structure which was first pointed out by Vittadini, and afterwards more fully described by myself in the Annals of Natural History. After the hymenial surface has dried up, they either retain the spicules, or are entirely stemless. In *Lycoperdon,* they are for the most part extremely minute, and are either smooth or finely echinulate; but in *Scleroderma* and *Polysaccum,* they acquire a larger size and more varied surface. In *Mycenastrum,* the walls of the peridium acquire a considerable thickness, being in some cases as thick as an ordinary shoe-sole; and a similar structure obtains in one species, at least, of *Scleroderma,* in which the peridium splits at maturity in a stellate manner, as it does sometimes in *Mycenastrum.* Where the peridium is double, and the outer walls are thick and coriaceous, while the inner are thin and membranous, we have, as in *Geaster,* a complete separation of the two; the outer bursting in a stellate manner and becoming ultimately reflexed, while the inner, which is either sessile or pedunculate, preserves its original position, and disperses its spores by means of one or more apertures, which are sometimes elegantly grooved or plicate. Where the outer coat consists of two layers, they sometimes partially separate; and while the outer preserves its convexity, the inner, which was first reflexed, becomes inverted, and is suspended from the tips of the laciniæ, so as to present a very curious aspect, of which advantage has been taken by the older herbalists to record many extraordinary fancies, giving the form of a human head to the inner peridium, while they made a sort of body of the outer. In a species from Ceylon, the peridia are seated gregariously on a thick mycelium, while in the curious Cape genus, *Broomeia,* there is no outer peridium, but in its stead a thick corky mass, in the facets of which the little peridia are seated.

369. It was stated that the inner peridium is occasionally stipitate. This stem is sometimes elongated in such a manner as to form a very prominent feature. In *Tulostoma,* the peridium is at first sessile, but the outer coat is ruptured at a very early stage, and the stem, which was at first very short, is rapidly carried up, and clothed with dependent furfuraceous scales. In *Batarrea,* however, where the outer peridium assumes the form of a distinct volva, consisting of several coats, inclosing a thick elastic gelatinous substance, the elongation of the stem is still more curious, attaining dimensions of one or more feet. The pileus, in this case, is greatly reduced, and is at first surmounted by a portion of the membranes of the volva, while the flocci exhibit distant spiral threads or perfect rings in their cavity.

370. The gelatinous element assumes a different form in the curious genera, *Mitremyces* and *Husseia.* Sometimes it forms a multitude of intricate columns, and sometimes assumes the appearance of scales, supporting the peridium, which is surrounded by a thick coriaceous or cartilaginous covering, which either splits off in the shape of a fissured calyptra, or hangs down in irregular segments; the inner peridium has

two distinct coats, of which the inmost, which immediately incloses the fruit, is small and suspended under the common orifice, or accurately fills the cavity. The orifice itself is curiously plicate, and is often beautifully ornamented with vermilion, as if laid on with a brush.

371. A very curious genus* has been sent me by Mr. Curtis, which occurs on the heads of fruit of *Cyperus Irio*, in the south of India. The peridium is double, very thin and membranaceous, about $\frac{1}{3}$ of an inch in diameter, the outer coat being traversed by a net work of veins. The central mass consists of straight flocci mixed with globose argillaceous spores, varying in diameter from $\frac{1}{5000}$ to $\frac{1}{10000}$ of an inch; each containing a large nucleus. The most singular point, however, is that the stem is a twisted mass of shining threads, resembling, though but distantly, the stem of *Mitremyces*. Whether this is really *Myxogastrous* or *Trichogastrous*, is at present uncertain. It seems to stand on the confines of both.

372. These Fungi are found in a great diversity of climates. *Lycoperdon* occurs in very high latitudes, as at Disco Island, and also in the heart of India; while *Bovista* exhibits the finest and most perfect species in the plains of India, though a frequent inhabitant of colder latitudes. *Geaster*, again, occurs in very different climates, but does not affect such cold latitudes, and is represented in the tropics by many species. *Broomeia* has at present occurred only in the south of Africa. *Husseia* has been found only on Adam's Peak, in Ceylon. *Tulostoma* ascends far to the north, but its finest species affect warmer climates. *Mycenastrum* is found only in warmer districts, as is also the case with *Batarrea*, which scarcely ascends higher than Norfolk. *Mitremyces* was supposed to be confined to the warmer parts of the United States, but the genus has now occurred in Van Dieman's Land, Java, the Cape, and in the parts of India to the north and north-east of Calcutta. On the whole, the nobler forms are those of warmer climates.

373. *Lycoperdon*, as stated above, affords some esculent

* *Aglæocystis Indica*, Berk. and Curt.

species; but beyond this the tribe is of little use in an economical point of view. *Polysaccum* yields a yellow die, and is much used on that account in Italy. The contents of dry *Lycoperdons* are used as tinder, as a styptic, and as an anæsthetic.

3. NIDULARIACEI, *Cda.*

Common receptacle bursting at the apex, horizontally, irregularly, or by stellate fissures, consisting of two or more layers, which sometimes separate and become inverted. Partial receptacles free, or attached by elastic threads filled with a compact mass of cells, of which those in the centre are sporophores.

374. This a small but most curious group of Fungi, differing in many respects from every other division. The uterus is highly developed, and consists of several distinct coats, which either burst with a stellate fissure above, or expose the general cavity by the separation of a little lid, or an irregular rupture. Within this cavity are one or more distinct sporangia, often immersed in jelly, either free or fixed by an elastic string to the common walls; sometimes exploded elastically by the inversion of one of the coats, and containing a cellular mass, surrounded again by several distinct coats. The contained mass is at first compact and cellular, but a cavity is at length formed in the centre, and the cells which terminate there bear spores at their tips, exactly after the fashion of *Hymenomycetes.* At present, the immediate connection with other Fungi does not appear visible, though partial peridia exist in *Polysaccum.* I do not, indeed, know of a single genus which connects the group sensibly with any other. *Pilobolus* presents merely an analogy; *Thelebolus* is little known; and *Atractobolus,* Tode, is nothing more than the eggs of a species of *Rhipignathus,* unless Fries has something answering to Tode's artificial character. Some wonderful tales respecting these eggs were told by Dr. Mantell. The inner membrane has precisely the same chemical reaction under iodine and sulphuric acid as cellulose, a circumstance which might in some measure excuse the assignation of such bodies to the vegetable kingdom, though the whole appearance is entirely that of minute eggs. The force with which the sporangium of *Sphæ-*

robolus is ejected far exceeds, in proportion, that which is exhibited by the projection of a shell from the largest mortar. Few objects are more attractive to the general observer than *Nidulariæ*, with their little nest of egg-like sporangia. *N. lævis* and *striata* are both pleasing, the one from the elegance of its form, the other by its striated walls. The species themselves are widely diffused; but there are many species closely allied to them, but especially to the latter, which flourish alone under tropical suns. The principal differences, however, consist in the fruit, for the external habit of many species differs very slightly. *Sphærobolus* has not yet been found in the tropics; but its love of the warm, damp atmosphere of a hot-house renders it very probable that it does exist in some of the tropical forests, on decaying wood.* It occurs in the southern hemisphere, in Chili.

4. PHALLOIDEI, *Fr.*

Head more or less clavate or globose, often stipitate, variously divided, composed of large cells with many intervening lacunæ, bursting through a volva consisting of jelly inclosed between two heterogeneous strata. Hymenium sinuous, convolute, variously situated, sometimes covering the whole head, sometimes only particular parts of it, external or internal, soon passing into mucilage, which drips out in drops dark with the minute spores.

375. The peculiar characteristic of this group is, that the hymenium when mature deliquesces, which is precisely contrary to what takes place in *Trichogastres*, to which tribe it is otherwise closely allied. All of the species, I believe without exception, are furnished with a thick volva, stiffened by a dense gelatinous mass. In an early stage the stem is rudimentary; but as the hymenium, which is precisely that of *Trichogastres*, except in its more watery consistence, approaches maturity, the stem, which is full of deep pits or cavities, suddenly acquires an enormous development. These at first are strongly compressed, but as the stem increases the cavities

* In this, as in so many other instances, we are indebted to the Messrs. Tulasne for a knowledge of the real structure. See Ann. d. Sc. Nat., sér. 3, vol. 1, p. 41.

acquire a rounder form, till at length their vertical tendency is so strong that the volva is ruptured, a circumstance which could only be effected by the exercise of immense force. Sometimes, however, instead of a stem, the receptacle of the hymenium has a similar structure, and has the same effect in rupturing the volva. The stem, moreover, is fixed at the base by a very small point, and could not remain erect without some sustaining force. This is supplied by the lobes of the volva, which do not turn back, like those of the peridium of a *Geaster*, but contract on the stem, thereby preventing its fall. The hymenial mass assumes several forms. Sometimes it is simply clavate, being perforate or imperforate at the apex; sometimes it is pitted like the pileus of a *Morchella;* sometimes the border is free, as in a *Verpa*, and beneath this are one or more frill-like appendages, which are either simply membranous or most beautifully reticulated, so as to hang down like an umbrella beneath the pileus. The pileus may be either entire or fissured at the tops, with the tips of the lobes adherent, as in *Lysurus*, or beautifully stellate, as in *Aseröe.* The rays are occasionally extremely numerous, as in *Calathiscus.* In those cases where there is no stem, the receptacle forms a more or less perfect network, sometimes reduced to three or four meshes only. The colours are often extremely beautiful, but these are mostly compensated by a most odious smell. Even, however, in those cases where it is most loathsome, and where the odour pervades the atmosphere for some distance, it is asserted that this is sometimes so modified as to become even agreeable. Notwithstanding such discouragement, the gelatinous volva of more than one species of *Ileodictyon* is eaten by the New Zealanders under the name of Thunder dirt, as is also that of *Phallus Mokusin* in China, while the head is supposed to be an effectual cure for ulcers. No other use seems to be made of these productions; but the dripping hymenium affords a welcome food to multitudes of flies.

376. They are essentially plants of warm countries, though the most common species, *Phallus impudicus* and *caninus*, ascend to high northern latitudes. The greater number of species, however, are found only in tropical or sub-tropical

districts. The coral-like *Clathrus* has its northern limit in the Isle of Wight and Devonshire. The largest species occurs in the west coast of Africa, but at present it is little known. It is difficult to conceive what object is answered by the network of such species as *Phallus Dæmonum*. When the pileus first bursts through the volva the meshes are comparatively small, but after this, when the hymenial surface and fruit have arrived at their full maturity, the network goes on increasing till it attains considerable dimensions. The structure of the hymenium can be seen only in specimens which have not yet ruptured the volva. The naked spores are seated upon spicules at the top of the sporophores, and are often more than four in number.*

5. HYPOGÆI, *Berk.*

Growing beneath the surface of the soil. Peridium adnate, very rarely separable. Hymenium sinuoso-convolute.

377. The peculiar characters of this group depend almost entirely upon their subterranean habit. In fact, some are far more closely allied to individuals of other tribes than they are amongst themselves, and it is only in deference to commonly received opinion, and certain general appearances, that I am inclined to consider them as a distinct tribe. *Gautieria* is but a subterranean *Sparassis*, without, indeed, any attempt at a volva or peridium; *Hymenangium* and *Octaviana* are reduced *Podaxinei; Melanogaster* is nearly allied to *Scleroderma;* while *Hysterangium* is very nearly related to *Phalloidei*. They all agree in having a sinuous hymenium, and in some cases the cavities are traversed by threads, as in *Myxogastres*. The nearest approach to a distinct external covering is in *Hysterangium*. In other cases the trama and external coat are perfectly confluent. In most of the species the substance is fleshy and becomes drier at maturity, but this is not the case in *Hysterangium*. In a few instances, as in *Hydnangium*, there is an abundant flow of milky juice when they are fractured. The spores in many species accumulate in such numbers in the cavities, as to make it certain that the spicules

* Berk. in Ann. of Nat. Hist., vol. iv., p. 155.

or sterigmata must bear a successive crop. The spores vary much in size, form, and sculpture, but not to such an extent as in the real truffles. One species of *Melanogaster* is eaten, which is perhaps the only use to which any of the tribe are put. The species abound in the south of England and Europe, and one or two species ascend as high as Sweden, which has, however, extremely warm summers. One or two occur in Australia belonging to the genera *Hysterangium* and *Hymenangium*, but they have not at present been fully studied, in consequence of defective materials. *Gauticria* occurs in central America, as does *Melanogaster*. *Rhizopogon* is found in South Carolina. Other species probably exist in the same countries; but, from their peculiar habitat, they are very likely to escape notice. The only fungus in the Himalaya collections approaching to them, was a half-subterraneous *Scleroderma*.

6. PODAXINEI, *Mont.*

Peridium entire or volvæform. Hymenium sinuato-convolute or lamelliform; situated definitely or indefinitely. Stem mostly penetrating the fructifying tissue, which dries up or withers, often leaving a pulverulent mass.

378. We arrive at last at a very curious tribe, consisting of species in some measure resembling each other in character, but of different affinities. They all agree in having a peridium or spurious volva, more or less confluent, with the cuticle of the pileus. *Polyplocium* and *Podaxon* have evident affinities with *Lycoperdon; Cauloglossum* and *Secotium* with *Hymenogaster;* while *Montagnites* is very closely allied to *Agaricus.* The young state of *Podaxon* has not yet been examined, but from analogy it may be presumed to agree with that of *Lycoperdon.* *Gyrophragmium*, *Secotium*, and *Cauloglossum*, have all the same sinuous hymenium, though more persistent than in *Lycoperdon*, in consequence of which the spores are not discharged in the form of dust; whereas *Polyplocium*, which has abundant threads traversing the cavities, though the walls are persistent, is one of the most abominable of Fungi, from the vast multitude of sooty spores which it sends out from its hymenium, the lobes of which hang down after the fashion of the spines of a *Hydnum.* In *Montagnites* alone

there are distinct gills, as decided as those of *Xerotus*. The genus is, in fact, scarcely distinguishable from a true Hymenomycete. The spores exhibit few peculiarities; and where they have been observed in situ, they are borne by short spicules upon the sporophores. The flocci of *Podaxon* (Fig. 5, *c*) exhibit a spiral structure. A species of *Secotium*, which is found

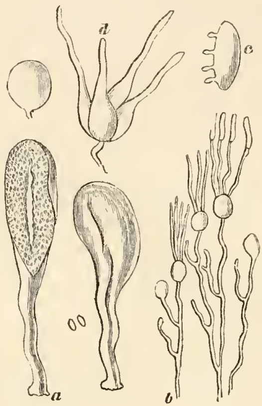

Fig. 77.

a. Cauloglossum transversarium, Fr., with spores. From Rev. M. A. Curtis.

b. Tremella viscosa. Threads with their sporophores, sterigmata, and spores.

c. Spore of *Dacrymyces deliquescens*, producing spores of a second order, or spermatia.

d. Sporophores of *Tremella mesenterica* in an early and more advanced stage, after Tulasne.

on the Swan River, is said to be one of the most delicious of esculent Fungi. A species of *Podaxon* has been used to cure ulcers. *Podaxon* affects mostly the nests of white ants, but this is not uniformly the case. The genus occurs amongst grass in Teneriffe, and Egypt. None of the species ascend higher than the shores of the Mediterranean. *Podaxon* occurs in the lower United States, as does *Cauloglossum*. *Secotium* is found as far south as New Zealand, a minute species of which genus occurs in the south of France. Two or three species are found in the south of Africa. They do not seem, however, to be common anywhere, except, perhaps, as regards the genus *Secotium*, which produces numerous individuals in Australia.

VI. HYMENOMYCETES, *Fr.*

Mycelium floccose, giving rise at once to a distinct hymenium, or producing a variously shaped naked or volvate receptacle, even, or bearing on its upper or under surface various folds, plates, prickles, &c., clothed with fertile hymenial cells.

HYMENOMYCETES.	Hymenium superior, or circumambient.	*Tremellini.*—Lobed, convolute, or disciform, gelatinous; fertile threads not compacted into a true hymenium.
		Clavariei.—Clavate or variously branched, rarely lobed or gelatinous.
	Hymenium inferior (except in resupinate forms).	*Auricularini.*—Fructifying surface even, without folds, tubes, prickles, &c.
		Hydnei. — Fructifying surface clothed with prickles.
		Polyporei.—Fructifying surface porose or tubular.
		Agaricini.—Fructifying surface lamellose.

379. The genus *Montagnites* has prepared us for that peculiar expansion of the hymenium which is the main feature of this great order. It is true there are species in which this is effected almost in the same way as in *Lycoperdon* or *Hymenogaster;* but, combining this character with the free development, except in a very few instances, and those in a mere state of transition, there is little difficulty in assigning each to its proper place. Analogous forms, indeed, occur to those in other orders; but an inspection of the fruit will at once suffice to distinguish them. One of the most striking instances is the external similarity of *Clavaria nigrita*, at least in a dry state, to *Geoglossum*.

380. They vary greatly both in form and substance. At first sight but little relation could be imagined between the thin outspread *Corticium*, and the noble stipitate *Amanita*, with its stem, volva, and ring; and yet no relation can be more undoubted if the resupinate form, consisting of nothing but mycelium and fruit, be traced up through all its multiplied gradations. Nor is the difference less as regards the hymenium, which in the one case is perfectly uniform, and in the other most beautifully and regularly plicate. In point of substance, we have forms as delicate and floccose as the most tender mould; while others are fleshy, gelatinous, corky, or even as hard as wood, and part assume the aspect of cartilage, whereas others are hard and resinous.

381. This order affords the most useful of the tribe, and at the same time the most dangerous. *Agaricus* presents a multitude of esculent species, some of which form no immaterial part of the food of countries in which they abound; but their use requires the exercise of much caution and discrimination, as the most virulent poisons are to be found in species closely related to those which are esculent. *Hymenomycetes* occur in all parts of the world, even in the warmest, and at the same time they ascend almost to the extreme limits of vegetation. They abound, however, most in temperate countries, especially in those where the hygrometer ranges high. Mere rain is not sufficient for their development, except the atmosphere is usually moist. The richest plot in the world, perhaps, for *Hymenomycetes* is afforded by parts of Sweden, where individuals are no less multitudinous than species. Indeed, no one can have a notion of the variety of forms, who has not had the opportunity of partaking of the treasures of that garden of mycology. By the kindness of Professor Fries I am in possession of authentic specimens of a very large proportion of the species he has described; and the perfect distinctness of the greater part, as well as the beauty, is most striking. Parts of America alone, which produces many of the most curious and rare European forms, vie with it in interest; and I have happily been in a condition to compare the mycology of both countries, from the possession of a large portion

of authentic specimens of species described by Schweinitz; as also by a host which have rewarded the researches of Lea, Curtis, and Ravenel, as well as a number of excellent collectors, whose industry and acuteness they have been enabled to engage in the pursuit. The most abundant localities in Sweden are those in which the woods consist of Conifers mixed with other trees; and one cause of the immense variety of species there is, that the woods of the middle of Sweden are so different from those of the south, insomuch that the mycology of the two districts is very different. On the whole, Great Britain, though possessing a considerable list of species, is not abundant in individuals, except as regards a limited number of species. The exuberance, even in the most favourable autumn, is not to be compared with that of Sweden or many parts of Germany. Many of the species which afford wholesome food there, occur here only in small quantities; and if people were dependent for food, in the months most favourable to mycology, on the fleshy Fungi, in the inferior oolite districts with which I am most familar, notwithstanding the very large number of species which occurs, a general starvation must inevitably arise, even were they as indiscriminate in their use as are the Poles and Russians. Other uses to which plants of this order are applied are very limited, and have either been already noticed, or will be mentioned under the respective heads.

1. Tremellini, *Fr.*

Gelatinous, more or less lobed and folded, rarely pezizæform, clavate or effused. Sporophores very long, produced on sporiform cells; not compacted into a continuous hymenium. Spermatia on separate threads or on processes of the spores.

382. The gelatinous substance is one of the most striking external features of this group, though it is not altogether distinctive, as genera exhibiting such a texture occur in other divisions. For the most part there is no appearance of mycelium, nor, indeed, of anything except the stroma, which is more or less developed, and does not give off a continuous stratum of compacted sporophores. The fructifying surface is always superior, and follows every inequality of the stroma, whether

it is simply spread out over the matrix, swelling into a rounded body, grooved so as to form an appearance like that of the brain of some animal, or, finally, variously plicate or folded, so as to present a large sporiferous surface. In *Exidia* the under surface is distinct from the upper, and generally clothed with short hairs or processes, which are sometimes very abundant, so that it is tomentose, velvety, or sometimes almost strigose; and in *Dacrymyces* there is occasionally, but not always, a sort of stem, as is also the case sometimes in *Coryne*. The most curious part about the *Tremellini* is the fruit which has only been lately explained. When I published my memoir on the hymenium, I was content to notice the fact of the singularity of its structure, but I did not venture to publish my sketch, as I did not fully understand the matter; now, however, it appears clear from the observations of Tulasne, which have been confirmed by many observers, that the hymenial surface gives rise to globose bodies, answering to the sporophores of the higher species. These, however, are sometimes more definite than sporophores are usually, exhibiting a concentration of colour and even septa, and sometimes divided into several lobes, generally four. After a time they give rise to a definite or indefinite number of elongated flexuous threads, which bear at their tips cymbiform spores. In some cases, these spores produce little bodies from their sides, the nature of which is not at present well ascertained (Fig. 77, *b*, *c*, *d*).

383. The similarity between *Tremella* and *Podisoma* (Fig. 6, *a*) was recognised years since, but it is only of late that their relation is found to be one of homology. The so-called spores of *Podisoma* are, to a great extent, identical with the sporophores of *Tremella*. The structure of *Podisoma* is, however, so exactly that of *Puccinia*, with the exception of the gelatinous element, that it can by no means be removed from the neighbourhood of the epiphytous fungi; and its habitat on living branches, on which it is to a great extent perennial, confirms the correctness of such association. The confluence of *Hymenomycetes* with *Coniomycetes* at these points is extremely interesting. It has been doubted whether some species of *Tremella* may not be mere states of other fungi, as,

for instance, *Tremella purpurea* of *Bulgaria sarcoides;* but there really appears to be no good reason for the notion. That *Dacrymyces Urticæ* is a condition of *Peziza Fusarioides*, is pretty well ascertained, but then it is not a true *Dacrymyces*. In *Næmetelia* the nucleus of the stroma has a white calcareous appearance, totally different from the rest, and peculiarly subject to the attacks of insects in the herbarium. The calcareous appearance does not, however, appear to arise from the presence of crystallised matter, but from a compact structure free from mucilage or jelly.

384. The greater part of this group are inhabitants peculiarly of temperate climates; but *Exidia* is an exception, which is abundant in all tropical climates; and one of the species, *E. Auricula Judæ*, is a perfect cosmopolite. A few only are so gelatinous as scarcely to admit of being well preserved for the herbarium. *Tremella* occurs in the warmer parts of North America, and is found in New Zealand. A species also occurs in the Himalayas. *Exidia Auricula Judæ* was once a popular remedy for sore throats, probably from some fancied resemblance of the hymenium to the fauces, and it is still occasionally sold in Covent Garden.

2. Clavariei, *Fr.*

Receptacle clavate, fusiform, or variously branched; very rarely gelatinous, hymenium circumambient, covering the upper part of the fungus, with or without a distinct barren stem.

385. The stroma is here decidedly elongated, and in many instances a stem is formed perfectly distinct from the hymenium, and differing sometimes in character from the rest of the plant. The form of the unbranched species is, in fact, the same as was already anticipated in some of the *Elvellacei*, as *Mitrula* and *Geoglossum;* but the structure of the hymenium is totally different. This follows the surface of the receptacle, and is generally without any decided inequality; in *Sparassis* alone the clavate form is obliterated, and we have the foliaceous or puckered state of some of the higher *Tremellæ*. Extension of surface is, however, in many cases attained, and that to a considerable degree, by ramification; in consequence of which, and of the great variety and beauty of colouring, the tribe contains

some of the most elegant and striking fungi. With a few exceptions, the more noble *Clavariæ* are not found in this country. In Sweden they luxuriate, as they do in the mountainous woods of Switzerland, where they form an admirable article of food; nor are some of our own smaller species to be despised.

386. Most of the species grow upon the ground, or on decaying leaves, either in open pastures or close woods. Some grow exclusively on decayed wood, and in this case often exhibit a well-developed mycelium, as is the case also with some of the terrestrial species. They affect temperate countries more especially; but the species which grow on wood, or their analogues, occur in the tropics, as do a number of species which approach in character and texture to *Thelephora.* Some of the species are very minute. *Typhula* is remarkable for the distinct development of the stem, while *Crinula* has but little hymenial surface at all. These smaller species often grow from *Sclerotia.* The nature of the connection is not, however, certain. *Typhula phacorhiza,* for instance, grows indiscriminately on *Sclerotium complanatum* and *scutellatum*; and it is improbable that both are contracted states of the *Typhula,* like the tuberiform base of *Agaricus tuberosus.* The genus *Calocera* reverts somewhat to the Tremelloid type, without, however, repeating their peculiar sporophores. *Sparassis,* a little contracted and almost hypogœous, could only be distinguished from *Gautieria* by its far smaller—altogether less conspicuous—spores. The minuter *Pistillariæ* are with difficulty distinguished from *Isaria.*

3. Auricularini, *Fr.*

Substance various; hymenium nearly even, without any regular folds or elevations; inferior except in the resupinate species; sometimes setulose.

387. Having disposed of the two aberrant groups *Tremellini* and *Clavariei,* we commence the regular series of *Hymenomycetes* proper, which by almost imperceptible transitions lead to the noblest genus of the order *Agaricus.* The four groups of which they are composed are distinguished generally by their even or only slightly rugged hymenium, by projecting prickles, by pores, or by gills. The members, however, of

which this vast collection of plants is composed, are connected so intimately with one another, and the whole mass is so natural, that it is scarcely possible to say where one genus ends and where one begins. Practice alone, and tact, can do this in the more difficult cases ; and it must be confessed that in different states the same species is often positively referable to three or more distinct genera, and it is only the possession of intermediate states which can put one in a condition to say which is the correct nomenclature. This, however, is not a question parallel with that which is so often quoted amongst the *Orchideæ*, but the difficulty arises from the very nature of the case. If pores, gills, and prickles alone were produced, no difficulty would arise ; but the gills are branched or connected by veins till they assume the appearance of pores; and the walls of the pores are split and broken up till they assume the guise of prickles. In consequence there will always be some doubt about certain species of *Dædalea* and *Irpex*, though there is none about the generic distinction of the more typical species ; and if some difficulty arise even where there is great diversity of substance, how much more between such Fungi as *Lenzites* and *Dædalea*, which agree in substance, but which typically belong to two distinct series.

388. The first group, then, consists of those species in which the hymenium is absolutely even, except so far as it follows the inequality of the matrix, or has merely faint raised points or lines disposed without any definite order over the hymenium. From the very nature of the case they are inclined to assume a radiating form; but no one could take them for gills, except possibly in some states of *Guepinia*. *Cyphella* is as essentially cup-shaped as any *Peziza*, and the only difference that exists between them is the non-production of asci. The genus, though consisting of obscure species, is of great importance, as connecting *Porothelium*, and thence *Polyporus*, with *Peziza*. *Craterellus*, again, assumes a pileate form, and is only distinguished from *Cantharellus* by the indistinctness of the folds of the hymenium. In *Craterellus lateritius*, Berk., which is *Thelephora Cantharellus*, Schwein., the veins are so distinct as rather to give the notion of a common Chantarelle imperfectly

developed, than a distinct type. A vast quantity, however, of the fungoid growths which appear on fallen timber and branches, exhibit mere differences of colour and substance, without any of hymenium, except that in some species there are little bristles, and in others peculiar processes, calling to mind those which exist on the hymenium of the higher Fungi, and which may ultimately prove sexual. They may be dry, waxy, byssoid or moist, tender or gelatinous, without much difference as to hymenium, and it is on this account that the species are so difficult to distinguish. The hymenium is essentially inferior, avoiding the light; and hence in many species, even those which are resupinate, when accidentally superior, it becomes inferior by the detachment of the pileus from the matrix. This occasionally takes place in most species to a greater or less extent; but in some it is normal; and a step further leads us to stemless but expanded dimidiate or flabellate forms. Precisely the same series of phenomena holds in all the other groups, a circumstance which shows that a form is not necessarily distinct because it is resupinate. Indeed, resupinate species are always to be regarded with caution, and resupinate forms even of nobler species may occur.

389. One genus essentially tropical, *Dictyonema*, is worthy of notice, because it has been considered an Alga. Like *Cora*, it grows in exposed damp places, on moss or other vegetables; and as it does not always perfect its hymenium, and is very generally felted with a species of *Calothrix*, no great blame can be attached to those who have misunderstood its affinities. Both in *Cora* and *Dictyonema* the hymenium cracks up into fragments, so as to exhibit the appearance of little parasitic *Pezizæ*. The substance of the pileus, in fact, grows so fast that the hymenium cannot keep pace with it, and so is broken up. *Cora* was originally referred to the genus *Ulva*, but with very little reason, even on principles which were generally received at the time of its first discovery.

390. But besides these there are forms essentially mesopod or lateral; yet even here, again, the mesopod may become lateral by only a partial development of the pileus. Both the lateral and mesopod forms, again, may become clavarioid by the

fissure of the pileus and the gradual obliteration of the upper surface, changes which may be traced with ease in the mesopod *Thelephoræ*, or in the stipitate forms; the stem may be developed at the expense of the pileus, and if wholly at its expense there will be no development of hymenium at all. In *Thelephora*, at least in the more typical species, there are always inequalities in the hymenium; and it is only the exaggeration of these which constitutes the genus *Cladoderris*, which, perhaps, is scarcely tenable. Mere size will not give it any title to distinction, for there are species of *Stereum* which vie with it in magnitude. One species in Guiana, *S. hydrophorum*, is remarkable for the time which it holds water. This appears, however, to be only an older form of a species whose cup is at first filled with branched processes, which give it the appearance of a nest. Many of the exotic species of *Thelephora* and some of our own exhibit a Clavaria-like form in consequence of the hymenium being disposed all round the processes of which it is composed; but the plan on which this takes place has already been stated.

391. As in the following tribe, there is a vast variety of colour, insomuch that many of the objects of which it is composed are attractive, especially where colour is combined with elegant form and sculpture. One caution is most needful, not only for beginners, but for all half mycologists. As all *Hymenomycetes* arise equally from a mycelium, and that mycelium may be spread out on the matrix, and may assume a stratum of cells, over the threads of which it is composed, before the other parts are formed, it is clear that the earlier stages, and much more the abortive and metamorphosed stages, of many of the higher species, before any hymenium is formed, may simulate *Thelephoræ*. A host of spurious genera and species have thus been admitted into scientific works. No species should, however, be allowed to be autonomous, which has not a perfect hymenium; and then care must be taken to distinguish spores and conidia. Gelatinous forms occur in this as in the following group. Some of those usually referred to *Corticium* belong, however, to *Tremella;* and *Auricularia* is scarcely distinguishable from *Exidia.*

392. The tribe is widely diffused over the world, and several of the species are cosmopolites. The central stemmed or lateral species affect especially warmer climates, but resupinate species are by no means altogether wanting in the tropics. *Stereum lobatum* in some of its forms is found in all sub-tropical countries; and if the species be taken in a wide sense, it extends into higher parts of the temperate zones. The species are, however, so closely connected with each other, that it is not always possible to say what is and what is not distinct. *Stereum rubiginosum*, for instance, may either be split into a dozen species, or considered as variable as *Fucus vesiculosus*. In its wider sense it is found almost everywhere. The species are in general so tough, or so insignificant in point of size, that they are not edible; and we are unable to point out any other use to which they are capable of being put.

4. Hydnei, *Fr.*

Fructifying surface inferior or amphigenous, beset with prickles, tubercles, &c., but never truly porous, rarely gelatinous.

393. *Thelephora* exhibits slight linear elevations or rugosities on its hymenium, but affecting rather a lamellar disposition than that of elongated aculeiform processes. We have, therefore, so far, nothing leading very immediately to this group, except, indeed, *Phlebia* is associated with *Hydnei*, in accordance with the views of Fries, an arrangement which is scarcely correct, though I have followed Fries in the system proposed in the vegetable kingdom. In one or two *Corticia*, indeed, the surface is slightly granulated, and if these granules be a little exaggerated or surmounted by one or more little pointed processes, it is no great step from *Corticium* to *Grandinia* or *Kneiffia*. *Grandinia* is, in fact, a *Corticium* with little decided granular elevations, which never assume the form of teeth or prickles. *Kneiffia* is a step further in advance, on account of the bristles with which the granules are crowned; and *Odontia* makes way rapidly for *Hydnum* in all its varied forms, resupinate, apodous, lateral, merismoid, and mesopod, with almost every conceivable gradation of substance, colour, and sculpture. We have species, accordingly, strictly membranous, others gelatinous, others again fleshy and excellent

for food; while a multitude of species are corky, and to a certain extent persistent. Woody species are very rare; but I have one species of *Sistotrema* perfectly ligneous, with enormously developed teeth, and perhaps one of the finest of the ligneous Fungi. In fact, so varied are they, that the species differ from each other more than the lower genera. In all these cases the hymenium is inferior, or merely resupinate; but in *Hericium* it is strictly amphigenous, insomuch that the genus may be considered as a group of simple *Clavariæ* consolidated into a single mass. *Sistotrema* and *Irpex* are approaches to the *Polyporioid* group, and are in their early stage scarcely distinguishable. *Radulum*, however, connects these with *Hydnum*, so that their association with the other genera is not unnatural.

394. The whole group affects temperate climes, and, with one or two rare exceptions only, has representatives in the tropics. One curious *Hydnum* occurs in Jamaica, and there are a few sub-tropical species, differing, however, but slightly from the forms of more temperate regions. There are some representatives in the antarctic regions, but the species have their centre in the northern hemisphere. The finest species abound in Sweden. A few occur all over Europe. *H. clathroides* is abundant amongst the Himalayas. Numerous species occur in Great Britain, but those of the mesopod division are rare. *H. repandum* is one of our best esculent Fungi, and I believe very safe; and a few more are esculent.

5. POLYPOREI, *Fr.*

Fructifying surface essentially porous, the pores constituting mere depressions in the substance, or formed by a folded membrane, so as to be separable from each other, or from the pileus. Substance various.

395. The essential character of this important division is the depression of the hymenium, in the form of more or less perfect tubes. Now, if the hymenial surface of the indefinite elevations of a granulated *Corticium* be entirely depressed, we have at once a *Porothelium*, of which an important Polyporoid form has lately been discovered by Mr. Spruce on the banks of the Rio Negro, a tributary of the Amazon. If

a *Porothelium,* on the other hand, be compared with some of the white *Tapeziæ* or *Solenia,* the external resemblance is almost perfect; but the one have asci, the other sporophores. If these scattered pores become approximate, we have the higher forms of *Porothelium* and *Fistulina,* which appears to us a true Polyporoid; and if they are connate through their whole length, we have, according to the degrees of confluence, a *Boletus, Polyporus,* or *Trametes.* We have here, again, the same series of forms as amongst the *Hydnei,* with the same variety of substance, colour, and sculpture; and, as in the former case, the size, length, division, &c., of the hymenial processes afford an infinite variety of characters. Where the tubes are only slightly connected so as to be divisible, we have *Boletus* or *Favolus;* where they are thin but not divisible, a *Polyporus;* and where the trama is thick and passes sensibly into the substance of the pileus, a *Trametes.* Large alveolar, rigid, hexagonal pores are the characteristic of *Hexagonia.* In *Fistulina* the pores are from the first perfectly distinct, and their tips are always free and studded with little granules, which give them a flowery aspect. In a few genera the pores are far less typical, formed rather by elevations of the hymenium anastomosing so as to form little areæ, than regular pores. *Merulius,* therefore, is on the one side confluent with the superior order; and on the other with *Craterellus. Laschia* is remarkable for its gelatinous substance, and approaches very near to *Exidia.*

396. The number of good species contained in the genus *Polyporus* is immense, and increasing every day. They may be divided into three great masses—the tropical, sub-tropical, and European species. Many of the tropical species, as *P. sanguineus, P. xanthopus,* &c., are found wherever the temperature is sufficiently high; while, on the contrary, many are local. The same species may occur in India and Cuba, without any intermediate station. Some species are common to the Arctic and Antarctic hemispheres, while others are confined to each. A few species, as *P. lucidus, igniarius, versicolor,* &c., are found in every variety of climate. In general, the species which affect warmer climates are not distinguished

by any striking characters; for though, as is usual, many of the finer species, such as *P. xanthopus* and *sacer*, belong to the tropics, they have their fair share of uninteresting forms. *P. sacer*, indeed, is a most striking object, and is regarded with veneration by the negroes of the West African coast. *Boletus* is very much confined to more temperate regions, while typical *Hexagoniæ* affect only the tropical. The bright scarlet of *P. sanguineus* has its representative in the warmer parts of Europe, in *P. cinnabarrinus*, a species which, however, extends also to the tropics. The size which is attained by some of these productions is enormous. Even in Great Britain, *P. fraxineus* is sometimes a yard across, and some of the softer species form masses large enough to fill a common cart.*

397. *Boletus edulis* is much esteemed as a delicate article of food, and some of the *Polypori* are esculent, but their close texture makes them, for the most part, very indigestible. Several species of *Polyporus* are used for tinder or moxa, while others form excellent razor-strops. *Polyporus officinalis* is a well-known purgative, the use of which is, however, now superseded by better remedies. Many of the species are very destructive to trunks of trees. It is true that in the first instance they grow on parts which are diseased, but their mycelium spreads with great rapidity, and the moment any growth of this kind appears the tree should be felled, or, if the tree is important as ornamental timber, the affected parts should be carefully removed, and a strong solution of sulphate of copper or corrosive sublimate be applied. A few of the species, moreover, are extremely destructive to wooden fabrics, the only remedy against which is perfect ventilation, winter

* I have given, in Lindley's Vegetable Kingdom, the result of close examination, comparative lists of Fungi in Java, Cuba, and the Philippine Islands, and something of the same kind in Hooker's Flora of New Zealand. It will be seen from these, how prominent a part the *Polypori* bear in the lists of exotic Fungi, where the climate is hot or equable; how local many of the species are, and how widely distributed others. It will be seen, too, how many European species are found in such localities. The details have been omitted here, in consequence of the mass of matter before me, which requires to be compressed into as small a space as possible.

felling, or, if this be out of the question, impregnation with such chemical substances as are destructive to the growth of Fungi. *Merulius lacrymans* is perhaps the worst of these, as its mycelium attracts moisture. A cellar which has long been dripping from its prevalence, will soon become dry when a strong wash of corrosive sublimate is applied. Several of the species are capable of a certain degree of growth in subterraneous localities, in consequence of which a number of very curious forms occur. Another peculiarity is, that as the hymenium is constantly deposited on the side which is turned towards the earth, if a specimen be accidentally reversed the hymenium gradually loses its own characters, assuming those of the pileus, and the contrary. Specimens in a state of transition are often very puzzling.

398. Attempts have been made to cultivate *Boletus edulis*, and a species of *Polyporus* is produced by roasting the branches of hazel-trees in Italy. The dense masses of mycelium belonging to *P. tuberaster* are capable of being transported thousands of miles, and on the application of moisture will produce a crop of pilei, as has been proved more than once in England. *Polyporus fomentarius* not only supplies Amadou, but has been manufactured into coarse clothing; and the pounded pileus of *P. igniarius* is mixed by the Ostyacks with snuff, whose narcotic qualities it is said to improve.

6. Agaricini, *Fr.*

Hymenium plicate, radiating from a common centre; the main divisions often connected by transverse processes, but not so as to form definite pores.

399. The only remaining group of Fungi, and that containing the noblest though not the largest species, is distinguished by the gill-like folds which form the hymenium. In some species of *Paxillus*, they not only separate with ease from the substance of the pileus, like the tubes of *Boleti*, but they are capable of being unfolded to a considerable extent; in other species, the substance which unites the two surfaces is so closely combined with each, that any such separation is out of the question. In the genus *Trogia*, however, there is a groove along the outer edge; and in *Schizophyllum*, the gills split in

the direction of their trama, at the same time rolling over on either side so as to present a very curious aspect. A few of the lower species are strictly resupinate, with scarcely any definite arrangement of the lamellar processes; and, indeed, in *Agaricus* resupinate species occur, but the gills always tend to a central or excentric point; and in a curious species from Borneo, there is a little columella to which they are attached.

400. No traces, at present, of anything like male organs have been discovered in *Hymenomycetes.* They have been looked for in the enlarged crystalline cells which project from the surface of the hymenium in many *Agarici, Coprini, Boleti,* &c., but without success. Conidia sometimes occur on the mycelium, and in *Agaricus racemosus* the stems bear a number of little processes exactly like *Stilbum,* which bear little stylospores. I have in vain looked for the contractile tissue on the upper side of the ring of *Ag. muscarius,* described by Hoffmann, in Bot. Zeit., 1853, p. 857.* Though he was at first inclined to consider the component threads of sexual importance, he subsequently abandoned the notion.†

401. The genera differ in substance, and in the nature of their gills. *Lenzites* contains species which are positively ligneous; in *Xerotus* the pileus is coriaceous; in *Lentinus, Marasmius,* and *Panus,* of a tough persistent texture; while in *Coprinus* the tissues are so crisp and delicate that they deliquesce in a few hours. *Heliomyces* has a subgelatinous substance, while *Russula* and *Lactarius* are remarkable for the vesicular character of their trama. *Agaricus* assumes a thousand forms and colours, with only slight modifications as to substance. A few species have a distinct universal volva; while in multitudes there is an arachnoid or woven veil attached to the edge, and sometimes entirely covering the gills. A few species are involved in a viscid or mucilaginous coat.

* Under a magnifying power of 363 diameters, according to Hoffmann, the delicate threads which grow on the upper surface of the ring are found to be sprinkled with a great quantity of gelatinous knots, from which project one or more quickly oscillating threads, terminated frequently with a little head, which occasionally becomes detached.

† For details of supposed spermatia, see Hoffm. l. c., 1856, p. 137.

Nyctalis is always parasitic on decaying *Lactarii*, and there are one or two Agarics, of which the most important is *A. Lovei*, with a similar habit.

402. As regards sculpture or vestment, they exhibit various peculiarities, especially in the latter respect, from the smoothest highly polished surface, like that of ivory, to the shaggy scales of *A. squarrosus.* Many of the lower genera contain but very few species, but almost all the more important divisions abound in species. *Lentinus* and *Marasmius* are the glory of tropical mycology, though both have numerous representatives, especially the latter in European woods. *Cortinarius*, which is scarcely represented in the tropics, has its centre in Sweden, where it abounds both in species and individuals. A straggling species occurs in Australia, and two or three amongst the mountains north of Calcutta, and a few in North America; and though England has many species, the quantity is not to be compared with what occur in Sweden. *Schizophyllum* is a species of warmer climates, and in them almost universal. It is a rare inhabitant of England, and for the most part imported. *Coprinus*, as the name implies, is a native of hotbeds and other exuberant soil. The growth is extremely rapid, insomuch that some species are capable of exhibiting every phase of growth and of decay in a few hours. They are the Ephemerides of vegetables. A species has been developed more than once in the course of a few hours, on the dressings applied to amputated limbs. The notion that they luxuriate, especially in tropical climes, has not at present been confirmed. Of all the genera, however, *Agaricus* is the most prolific. After all the eliminations which have been made, there remain at least a thousand truly distinct species; and when it is considered how little the tropical kinds have been studied, it is certain that many additions will yet be made to the genus. Notwithstanding the notion that these productions are the growth of the fortuitous concurrence of certain elements, it is allowed by those who have studied the genus well, that in the whole vegetable kingdom there are no more decidedly distinct species than in *Agaricus*. The species of tropical climates are in general of little beauty; but in the lofty mountains of

Sikkim, which is, perhaps, the wettest country in the world, species abound which exhibit enormous dimensions combined with great beauty. In many cases the distinctions, though clear, are very slight between Himalayan and European species, while many of them are decidedly the same. Agarics ascend as high as Nova Zembla, and occur in Kerguelens-land. Their abundance depends upon a moist atmosphere and sufficient temperature. Most of the species are destroyed by frost; a few only, like *Ag. velutipes*, are capable of enduring it without serious injury. In an economical point of view, the *Agaricini* are of considerable importance. A few *Marasmii*, *Lactarii*, *Russulæ*, and *Cantharelli*, are esculent, but their numbers are not to be compared with the excellent species produced by the genus *Agaricus*. At least a tenth of the species are esculent, and a fifth may be pronounced as affording good if not agreeable food. Russia, Germany, the South of France, and Italy, with some other European countries, profit by the abundance of food they supply; and if good food were less abundant in England, there is no doubt that the riches which lie scattered about would not be neglected as they are. The prejudice against Fungi is so great at Paris, that artificially raised mushrooms are almost the only ones of the genus that are admitted into the market, and in London the number is confined to about six. The only one which is extensively cultivated is the common mushroom, a species which occurs, under some form or other, in almost every part of the world. Mushrooms have hitherto, for the most part, been cultivated under sheds, or in caves and vaults; but it is now well ascertained that early mushrooms may be obtained in the open ground, of at least as good qualities as those cultivated at greater expense. I have endeavoured to introduce an esculent species from Australia and South Carolina; but, probably from the specimens having been kept too long before transmission, the spawn has never run. The consumption of mushrooms in Paris is something enormous, and the whole that appear in market are the produce of the catacombs. *Marasmius Oreades* is superior to the mushroom in point of flavour, and makes a most excellent catsup, as do also *Ag.*

procerus and some others. Most are used when fresh; but *M. Oreades, P. Georgii,* and others, may be preserved in good condition when dry. The most delicious of all Fungi, perhaps, is *P. cæsareus,* which has not yet occurred in England. A very closely allied form or species occurs amongst the Himalayas, but we have no information as to its esculent qualities. Many of the species are eaten by the Bhoteeas, who are reduced by famine to eat some species which would not otherwise be supposed fit for food. In Russia and Germany enormous quantities are gathered for winter use. The vinegar in which they are preserved seems to neutralise the alcaline poison which they contain, for the species are gathered without much discrimination. Some specimens submitted to me appeared to be *Lactarii,* but in too altered a condition to enable me to ascertain the species. The narcotic qualities of *P. muscarius* are well known. It is a useful poison for flies and other insects, but it is also a strong narcotic, producing inebriation and communicating its properties to the urine of those who consume it. An accident was nearly happening lately, in consequence of some being consumed for breakfast, though intended for the preparation of fly-water. Fortunately, only a small quantity was eaten, and the penalty was a temporary intoxication, as complete almost as that produced by tobacco to persons unaccustomed to its use.

403. The greatest objection to the use of Fungi in food, is that the qualities of the same species are so very different in different countries. The common mushroom has proved fatal in Italy, and is most carefully excluded from the markets; and parallel cases might be adduced with regard to other species. This does not appear to depend upon any idiopathic phenomena, but upon the intrinsic character of the individual specimens. In all there is a small amount of poisonous matter, and the quantity of this in any given species is extremely uncertain.

404. I have already, in the general observations on Fungi, touched upon the abnormal forms which are occasionally assumed by the mycelium, and which have given rise to so many genera. It has been seen, moreover, that spurious

genera have arisen in a similar way from the various forms of fruit produced in different species, some of which are undoubtedly representatives of sexual distinctions, and some possibly endowed with capability of impregnation. The different terms conidia, stylospores, and spermatia, must at present be regarded as more or less indefinite and uncertain. But apart from these circumstances, Fungi undergo great changes in form and habit, so as to make their study very difficult.*

405. The spores and sporidia afford good characters, provided so much stress is not laid upon particular appearances, as to lead us to pronounce species different when the fruit is merely in a different stage of development. The same species may at different times have simple, uniseptate, or multiseptate fruit, and its form will vary in different asci of the same individual, though some general characters may be exhibited by all. The size, again, varies very greatly, so that the nicest microscopical measurement can be taken only as an approximation. In *Xylaria pedunculata*, for instance, I have seen highly nourished individuals produce sporidia at least twice as long, with proportionate breadth, as in the normal plant. The same species also, as observed above, gives an example of the reduction of a large stipitate species with a sclerotioid rooting base, to a single, almost naked, perithecium. It has been shown, too, that the ostiola of the perithecia are equally variable in length.

406. The spores of the sporophorous Fungi vary in a similar manner. In the genus *Hymenogaster*, where the characters depend mainly on the spores, it is scarcely possible to separate many species with certainty, on account of the extreme variations assumed in different specimens, both as regards form and sculpture. But if various forms are assumed by the fruit, much more is this the case with the receptacle. The same species, according to varying circumstances of position, moisture, temperature, and other accidents, may be perfectly sessile, seated on a distinct stem, with an orbicular pileus, or this

* See, for further illustration of the duality of Fungi, Tulasne, in Ann. d. Sc. Nat., sér. 4, vol. 5, p. 108, published while this sheet was under proof.

same pileus may become lobed and perfectly lateral, without in the smallest degree impairing the certainty of its distinction, or, finally, the receptacle may vanish altogether, and nothing be left save a resupinate stratum of pores. One of the strongest instances is the resupinate Hydnoid form of *Polyp. sanguineus*, which has given rise to *Hydnum cinnabarinum*, Schwein., and *Odontia albo-miniata*, Berk. and Curt. Where the receptacle is further ramified, there is frequently every shade between a simple stem, and a mass almost as dense and as repeatedly branched as a cauliflower. Added to which, the same species may in different circumstances be perfectly dry or thickly viscid, smooth or tomentose, naked or scaly, with many other variations ; while in colour we may have tints as manifold as exist in many species of Phænogams. Where the flocci are the leading feature, their ramification, colour, and composition undergo multitudinous changes. No one, at first sight, could conceive that a *Coremium*, with its compound stem, was but the same thing with a *Penicillium* altered by superabundant moisture. The business of the Mycologist is to keep his eye open to such changes, and their proper value, if he wishes to escape the errors which have been committed by so many superficial observers. In some cases he has a ready excuse in the deficiency of his materials, but he cannot plead this with regard to widely diffused forms.

407. A few simple directions may be given in conclusion of the whole subject of Fungi, for preserving them for the herbarium. The greater number of Fungi may be preserved exactly like Phænogams but as they often contain the eggs or larvæ of insects, they require some care in looking over, till the stock has completely died out. They will require brushing occasionally with corrosive sublimate and turpentine, for, though one application will destroy the larvæ and perfect insects, it will not destroy the eggs. Some of the larger species can only be made perfectly free by submission to the heat of an oven. Moulds, and such delicate productions, easily part with their spores. The best way, therefore, is to wrap them lightly, as soon as gathered, in thin paper screwed up at either end. Their greatest enemies are minute acari, which are readily

destroyed like larger insects with the sublimate wash, but, unfortunately, not without injury to the specimens. *Myxogastres* will not admit of pressure when half grown. Specimens must, therefore, either be left till they have arrived at perfection, or they must be dried by exposure to a hot atmosphere. When perfect they are easily spoiled by heavy weights, and are best preserved in little shallow boxes; which may be so contrived as to admit of easy insertion with other specimens in the herbarium. In *Phalloidei* and a few of the larger Gasteromycetes, where the structure is rapidly changed after the formation of the spores, it is advisable to save a few specimens in spirits. This is, however, a plan, which, for many reasons, I should not recommend to be carried out on a large scale. As subsidiary to other specimens, individuals so preserved are always valuable; but they lose so many characters, that by themselves they are seldom available for description.

408. The greatest difficulties are presented by the fleshy Fungi. A great many of these, however, by proper care admit of excellent preservation. Very useful specimens may be prepared after the excellent method proposed in this country by Klotzsch, after Lasch;* though I think the plan should not entirely supersede the more ordinary mode. A clean section is made exactly down the centre of the fungus, and a thin slice removed from each half, which, when carefully dried, gives the details of the gills, the cavity of the stem, and the form of the fungus. The two half pilei are then separated and dried after the gills and flesh have been removed, and the two half stems after a little of the more solid matter has been taken away. Admirable specimens may be prepared in this way with a little nice manipulation and care in the renewal of the drying paper with sufficient frequency. When the specimens, after being glued down, are deposited in the herbarium, they can only be kept free from insects by frequent inspection, and by the room in which they are placed being perfectly dry. A fresh brood of insects will sometimes arise in specimens which have been impregnated with the sublimate;

* Linn., vol. v., p. 478 and 626, tab. 9, Klotzsch in Hook. Bot. Misc., vol. 2, p. 159.

though such specimens are far less liable than others. A spirituous solution is not well calculated for Fungi, as it is apt to change their colours. Dr. Léveillé informed me that he kept his Fungi clear of insects by always having a paper of fresh Polypori, such as *P. versicolor*, &c., amongst them, as they are greatly preferred to any other. I have, however, never tried this plan myself.

b. Lichenales, *Berk.*

Aërial mycetals deriving nourishment, for the most part, from the surrounding medium, and not from the matrix, constantly producing in the thallus green bodies, resembling chlorophyl (gonidia), either singly, in little bundles, or in moniliform rows; fruit contained in asci, or, as regards secondary fructification, seated on sporophores.

409. The principal points which distinguish Lichens from Fungi are their mode of growth, their living at the expense of the surrounding medium, their mostly perennial endurance and slow growth, and the production of gonidia. If the true Lichens be considered by themselves, their peculiar texture, tartareous and crustlike in a vast quantity of species, and in almost an equal number rigid and often brittle when dry, but flaccid and flexible when moist, is characteristic without having recourse to the fructification. If the Collemals be added, we have gelatinous fronds approaching very near, in point of texture, to many Algæ. The fruit is formed after the Ascomycetous type, and appears either under the guise of a distinct perithecium, as in *Sphæria*, an exposed disc, as in *Tympanis*, or a linear and frequently branched receptacle, as in *Hysterium* or *Glonium*. So far there is little or no difference between the fruit of Ascomycetes and Lichens. It appears, too, from the labours of Itzigsohn, Tulasne, and others, that in many cases there is distinct dualism, one form of fruit following the ascomycetous type, the other the sporophorous. Whether any autonomous genera exist with naked spores is extremely doubtful. Both forms, however, exist in general together on the same plant. In every case, except *Abrothalus*, and one or two allied parasitic Lichens, Tulasne considers

the naked fruit as spermatia ; in those he regards them as stylo-spores. But of this more hereafter. But besides these, there are abundant globular bodies of a vegetable green produced from the threads of the thallus. The origin of these has only very lately been studied. I had myself a good opportunity of ascertaining their development from the threads of the mycelium, in specimens developed within the vessels of pine wood picked

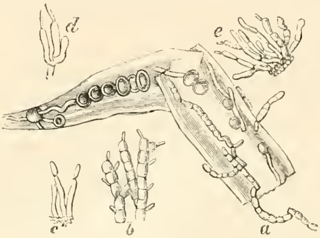

Fig. 78.

a. Wood cell of White Spruce much decomposed, filled with mycelium of *Parmelia parietina*, bearing gonidia.

b. Spermatia on fertile threads of *Umbilicaria pustulata.*

c. Ditto of *Urceolaria calcarea.*

d. Ditto of *Urceolaria cinerea.*

All highly magnified. The three latter after Tulasne, to whose treatise on Lichens, in Ann. d. Sc. Nat, 1852, every writer on the subject must be deeply indebted, and of which I have largely availed myself.

e. Threads and spermatia springing from wall of spermatogonium of *Borrera ciliaris.* From a sketch by Mr. G. H. Hoffman.

up by Captain Inglefield in the arctic regions, and figures have lately been published by Speerschneider in the Botanische Zeitung for 1854.* In many Lichens these bodies obtain access to the external air by means of rents in the upper surface, of more or less regularity, and are washed off after losing a little of their vivid colouring. The colour originally is always green, but it is modified by external circum-

* According to his observations they spring partly from the medullary layer, and partly from the tissues with which it is in immediate connection.

stances. In *Parmelia parietina*, when growing in the shade it is changed into a greyish tint, but when exposed to the full sun it acquires the same tint as the outer crust itself. The modifications of form and colour in this species, according to outward circumstances, are fully described by Meyer, Entwickelung der Flechten, p. 220.

410. Lichens, like Fungi, spring in the first instance from a branched mycelium, consisting of numerous intricate, often anastomosing, threads. They gradually give rise to a compact mass, assuming various forms and texture. The outer coat is merely a protective surface, consisting of dense compact cells, or threads so closely interwoven as to simulate cells; the inner, though differing in various species, retains more of the original structure, and gives birth beneath to the fibres by which the plant is often attached to the surface (hypothallus), or to a spongy mass, as in *Placodium*, and sometimes to an intermediate stratum of gonidia, with or without a compact mass, similar to the cortical layer, or that which immediately underlies the hymenium; while above it produces on the one hand the gonidia, or on the other the pycnidia, spermatogonia, and shields or other form of fruit. Where the development is abnormal, in consequence of peculiar conditions of the atmosphere, or from defect of light, the filamentous portion may be alone developed, or the whole plant may be broken up into a myriad of dustlike bodies, or the filamentous and pulverulent condition may exist together, and hence arise the dusty *Lepra- riæ*, the semi-filamentous *Lepraria latebrarum*, and some confervoid conditions. In other cases the thallus may be indefinitely extended, with an abundant development of patches of gonidia, as in the various kinds of *Variolaria*. On exotic barks many curious forms occur, which it is impossible at present to connect with their original parents. The different exotic *Hypochni* are, probably, mere degenerations of some Lichens; and there are other hymenomycetoid expansions, as *Thelephora pedicellata*, Schweinitz, which owe their origin to the same cause. *Chrysothrix* is probably a state of some Lichen, and the same is clearly the case with *Byssocaulon*, Mont. The genus *Cephaleurus* arises from an abnormal

development of the filamentous element of *Strigula*, a genus in which the cortical element usually prevails. *Cœnogonium*, on the contrary, appears to be a normal form, remarkable for the almost total suppression of the upper stratum. The place of growth is similar to that of *Dictyonema*, and its habit is very much the same. It is just possible that the various species of *Chroolepus*, which have some resemblance to *Cephaleurus* (Fig. 81, *a*), may be peculiar states of certain Lichens, their reproductive bodies being very similar.

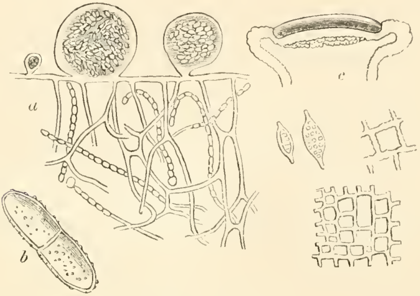

Fig. 79.

a. Section of a *Collema*, showing new fronds arising from the surface. From Noukaheva.

b. Sporidium of *Biatora marginiflexa*, Bab. From New Zealand. Communicated by Dr. Hooker.

c. *Leptogium bullatum*, showing a section of one of the apthous processes with its fertile disc, the sporidia and external cells of the frond. More or less magnified. From Assam. Communicated by Dr. Hooker. It is the form figured by Swartz, in Lich. Amer.

411. If the Collemals are associated with Lichens, which appears to me the most natural arrangement, we have still, in most cases, the medullary and cortical layers with gonidia, disposed frequently in long moniliform threads (Fig. 79, *a*); but we have in addition an abundant gelatinous element, in consequence of which, many are hard and rigid when dry, and when moistened resemble closely some of the Algæ. Indeed, some states

of *Collema* are hardly distinguishable from *Nostoc* (Fig. 79, *a*), though there does not seem any reason to believe, with some authors, that the two are merely different stages of one and the same plant, or that one passes or is transformed into the other. If the views of Fries are to be adopted, *Nostoc lichenoides*, and *foliaceum*, are merely *Collema limosum* and *flaccidum*, growing in a place so saturated with moisture that no shields can be produced, and that these species, if removed to a drier situation, perfect their fruit. He informs us that after he had ascertained this rule, he was able to discover the fruit of many species, as *Parmelia conoplea*, *lanuginosa*, *gelida*, &c., which he had never found in fructification before, and the abnormal *Lepraricæ* of dark fissures in rocks, &c., were referred to their proper origin.*

412. There is no doubt that Lichens are normally aerial plants; but a few species, as *Verrucaria submersa*, are always immersed, and some species of *Endocarpon* flourish when exposed to the spray of torrents, by which they are occasionally submerged. Were there no distinct mode of fructification in *Nostoc*, we might readily allow its identity with *Collema*, or at least there would be nothing to excite much reluctance in admitting it; but the mode of reproduction in *Nostoc* is well ascertained (p. 139), and the species are so closely connected with *Anabaina* and other genera, as to make the matter at least highly improbable. Meanwhile it is quite certain that many Lichens, in their origin, appear under the form of minute Algæ, and that several so-called species of *Hæmatococcus*, &c., are merely early stages of the development of Lichens, which may in their infancy present either a filamentous or furfuraceous mass. Facts like these, when well ascertained, illustrate the true nature of organisms and their hidden affinities; but it is only when they are superficially examined, that they lend any support to the doctrines of equivocal generation. Meyer

* The rule may hold good in many cases as to the effect of variation of locality, on such nearly allied organisms; but it does not follow, that because the early stage of a *Collema* may resemble a *Nostoc*, every *Nostoc* is an early stage of a *Collema*.

and Kützing may teach us much as to the early stages of these plants, but their conclusions must be received with the greatest caution. Indeed, it is sometimes difficult to know what authors mean. Agardh, for instance, when he asserts so positively that the tissues of Phænogams are true *Confervæ*, only means that they are homologous; and so again when he talks of the conversion of animals into Algæ, or the contrary; or when again he speaks of other supposed metamorphoses of Algæ, he does not mean what the words imply, for in other places he declares expressly that the changes of Algæ into Lichens are mere assumptions by the Algæ of Lichenoid forms.

413. The forms assumed by Lichens are extremely various, though there is in general great similarity of fruit. Even in the same genus the most different habits prevail, and, as has been seen before, the same species can assume very various forms under differing circumstances, so that two states may even be occasionally considered as belonging to different genera. This does not, however, always prove that the genera are badly founded, but that the species are not well circumscribed. Fries has done a great deal towards the reduction of anomalous forms to their true originals; and if he has sometimes gone too far, and has not attended sufficiently to characters afforded by the fruit, he has still done good service to the cause; and, notwithstanding the labours of Montagne, a similar reform is wanted amongst exotic species.

414. Those Lichens which are nearest to Fungi—namely, the *Verrucariæ*—have so little crust, that they are not always easily to be distinguished. The *Verrucariæ*, however, grow very commonly on living bark, a very rare circumstance amongst true Fungi. Still, at some stage of growth a mycelium or obscure crust may be traced; and, indeed, it is self-evident that it must exist, as, without a medullary substance no perithecia or asci could be produced. It must be remembered, too, that the perithecia are not produced singly, but in a common mass, and there must, therefore, be a common mycelium. This, however, may traverse the young tissues of the bark without producing any cortical stratum, and will be recognised

by merely a slight stain in those parts of the bark which produce perithecia. In *Opegrapha*, *Arthonia*, and the neighbouring genera, a crustlike thallus of greater or less thickness is produced, sometimes tartareous, but often hard and firm, with the surface even, or cracked and granulated. Except in the most obscure cases, gonidia are always present, however thin the crust may be.

415. The crustlike Lichens are, however, by no means confined to the perithecial or opegraphoid species. Whole series occur, belonging to *Lecidea*, *Lecanora*, &c., where the thallus is crustaceous, and sometimes the medullary stratum approaches in character to the vesicular structure of the cortical. By slow gradation the crust exhibits foliaceous granules and expansions on its surface, sometimes obscure, but at length distinct, and then it is but a step to the expansion of these minute fronds into regular leaflike processes, though still retaining the same essential structure. These fronds may be smooth below, or densely velvety or spongy, while occasionally in the midst of the downy clothing there are regular pits exposing the inner substance. If the fronds are very narrow, we have fucoid forms, and much more so when the thallus is cylindrical and either free from external organs, as in *Usnea*, or sprinkled with little fronds, as in *Cenomyce*. The medullary stratum in the highly branched species forms a tough cord in the centre, which is at length exposed by the cracking of the less extensile cortical layer.

416. The fructification is, in true Lichens, contained in distinct discs or perithecia, exactly as in Ascomycetous Fungi. The hymenium, or thalamium as it is often called, gives rise to asci and paraphyses, the tips of which are often charred by exposure to the sun. In some cases, however, they produce distinct bodies (Fig. 80, *d*), which are probably reproductive. The sporidia themselves vary much in form and colour, and are often more complicated than in Fungi. Few things can exceed in beauty, as microscopical objects, the sporidia of some species, though Fungi may vie with them even in this respect. In *Gassicourtia* they are of a bright scarlet, in *Sphærophoron* of a more or less deep blue, while in other

species they are olive, golden yellow, or brown. There is no doubt that the species which at present have been observed to produce nearly naked spores, as *Pyrenotheæ*, are mere conditions of others, though the normal form of the species may not hitherto have been detected.

417. Besides the true fruit, a multitude of species exhibit in different positions minute perithecia, producing from their lining wall myriads of minute bodies (Fig. 78, *b*, *c*, *d*). The tissue which supports these bodies is not always the same; sometimes it consists of short simple sporophores, as in *Phoma;* sometimes of branched articulate threads, as in *Cystotricha;* sometimes of compacted cells. Their function is not at present ascertained. Itzigsohn pronounced them to be spermatozoids, in consequence of apparently spontaneous motion; but in such minute bodies molecular motion may often exist, without anything vital. We have at present no proof that anything like real impregnation takes place. We may not, indeed, presume that impregnation cannot take place in Cryptogams, save by spermatozoids, because, where it has been ascertained, the impregnating bodies resemble somewhat those in animals; but we cannot assume the function of these bodies without proof. In a few cases, pycnidia are produced. This is, however, only in *Abrothallus* and *Scutula.* The latter has at the same time spermatogonia.

418. It is curious that the nature of these black specks was not ascertained before, because they were indicated as the probable male organs by the earlier Cryptogamic authors, and readily attract the eye in many species, as, for instance, in *Borrera ciliaris.* Their contents, however, cannot be seen without a clearly defining microscope.

419. The organs which produce the spermatia or stylospores are not always of the same form or character; sometimes, as in *Cetraria* and *Cladonia,* they are naked, like the perithecia of some species of *Cordyceps;* while occasionally the cavity of the spermatogonium or pycnidium is not simple, but sinuous or multiple, as in homologous bodies in Fungi. The granules themselves, too, vary in form, as do the bodies on which they are supported; facts which have their exact parallel in Fungi.

They are frequently strictly linear, and of very different length, whether straight or curved, but they are also rounded at either end, and oblong or elliptic. They are immersed in a thin gelatinous mucilage. In some species the cavity is traversed by anastomosing threads, as in *Ramalina farinacea,* while in other cases, as in *Parmelia physodes,* there are articulated paraphyses, the terminal joints of which are the largest. They have never yet been found to possess flagelliform appendages, nor have they any true motion, though, like other minute particles, they occasionally exhibit the Brownian molecular activity. If they are really capable of impregnation, they probably act upon the sporidia when already formed, as the spermatozoids do on the spores of Algæ. There is no reason to believe, as has been asserted, that they cause the formation of the sporidia.

420. In all those cases where similar bodies have been ascertained to exercise sexual functions, the bodies are developed within peculiar cells, and the remark may be extended to the animal as well as the vegetable world. This difference is, however, no conclusive proof against their functions, though it appears to me quite as probable that they should be a mere secondary form of fertile fruit, as sexual organs. I do not think it necessary to describe at length the notions of Bayrhoffer, as they are inconsistent with facts, and are either mere theories, or rest upon imperfect observations.

421. Every Lichen consists of at least the external, gonimic, and medullary strata, beyond which there is frequently another gonimic stratum, and basal cells or filaments. Both the true fruit and gonidia proceed from the medullary layer; of which, in point of fact, the other coat is a continuation only; the threads of which it is composed being condensed into a close stratum so as to be hard and horny, and to present an apparently cellular mass. The fruit, however, seems in no case to be formed immediately from the external stratum, though both in the spermatogonia and perithecia there is a compact cellular stratum, giving rise immediately to the fertile sporophores or asci, which simulates in point of structure the external coat. In a similar way the inferior stratum is formed by the lower portion

of the medullary mass, whether simply presenting a cellular mass, or more or less decidedly filamentous, or furnished with hair-like simple or branched processes. In proportion as the supporting cellular tissue of the hymenium makes its way through the outer coat, more or less perfectly, the shields are bordered by the thallus as in *Lecanora*, or by their own basal substance, as in *Lecidea.* The hymenium consists of distinct asci, as in Pyrenomycetous fungi, accompanied by articulated and often branched paraphyses. The application of iodine, even without sulphuric acid, produces a deep blue in the asci and paraphyses; the terminal portion of the latter, however, which is altered in chemical composition by constant exposure to the weather, is not affected. The asci and their paraphyses are so closely connected by a firm gelatinous substance that it is often very difficult, without the assistance of some acid, to separate them from one another, so as to obtain a clear view under the microscope. Mere compression is not always sufficient, and very strong compression is seldom advisable in microscopical observations. The contents of the spores become brown on the application of iodine, while their epispore is unaffected, and does not strike blue on the application of sulphuric acid, which does not affect it, except highly concentrated. Though the sporidia are often far more complicated in structure than the sporidia of Fungi, their epispore is usually smooth, except in such cases as *Solorina saccata*, *Thelotrema exanthematicum*, and *Biatora marginiflexa* (Fig. 79, *b*), which latter has enormous sporidia, attaining a length of $\frac{1}{200}$ of an inch. In *Pertusaria Wulfenii*, though smooth when expelled from the ascus, they soon become minutely granulated; but these granules are merely the commencement of a peculiar germination.

422. Lichens are essentially the creatures of light. They cannot, of course, exist without periodic moisture ; but they are capable of enduring long drought, accompanied by heat, and are not impatient of considerable degrees of cold. The same species, therefore, which will pass through all the phases of vegetation, up to the perfection of its fruit when properly exposed, will in a less favourable situation perfect only its frond,

which may be sprinkled with a few heaps of gonidia, while in shady crevices the frond itself will not come to perfection, but will assume the form of a *Lepraria*. It is very necessary to attend to these circumstances in the determination of species, and more especially in ascertaining their value.

423. Lichens occur in various situations. A large portion of them grow on exposed rocks, not excepting even the softest chalk, the barest flint, or the hardest quartz; the top of the mountain and sea-shore are equally productive; for the salt spray does not impede the growth of many species. Trunks of trees, again, or fabricated wood, support a host of Lichens, which are not unfrequently similar to those which grow on rocks. Dry, exposed soil, whether peaty or not, sustains its own species; while damp mossy woods or open heaths contribute many kinds, sometimes of such a shrubby habit, and in such numbers, as to hide the soil. The same species may, however, occur indifferently on rocks, trees, or soil; while it may be capable of enduring considerable climatic differences without much variety of form or habit. In some localities the species on trees and rocks are so exuberant as to conceal them scarcely less effectually than the terrestrial species do the soil.

424. Many tropical and one or two European species occur on leaves. A few of these are simply superficial, in which case the leaf serves merely as a base of growth, in the way of any other indifferent substance. It frequently, however, happens that the connection between the leaf and parasite is far more intimate; the Lichen originating after the fashion of many Fungi, beneath the true cuticle. This is the case with most, if not every, species of *Strigula*. To ascertain this fact, however, they must be examined in an early stage of growth.

425. The uses to which Lichens are put are of various kinds, and sometimes of considerable importance. *Cetraria islandica* affords a nutritious mucilage, in consequence of its containing a considerable proportion of amylaceous matter; though not in the granular form in which it commonly exists in vegetables, but diffused through the whole mass. It acts at once as an aliment and tonic, but is not adapted for forming a large portion of food,

in consequence of its disagreeable bitterness. The greater portion, however, of the Tripe de Roche, of which so much is said in Sir John Franklin's Narrative of his Overland Journey, was derived from the genus *Gyrophora*, in which the bitter principle is much more abundantly present, producing diarrhœa and other bad symptoms. *Lecanora esculenta* and *affinis* are largely used by the inhabitants of the countries east of the Levant, and in some parts of the north of Africa, to mix with wheat in grinding. The portion of nutritive matter which they contain is so much gain to the general stock; but such an immense quantity of oxalate of lime, nearly 66 per cent, is mixed with it, that the flour which results from the mixture is comparatively innutritious, and to some constitutions, where there is a tendency to what is called the oxalic diathesis, must be very injurious. These species are found scattered over the surface of the ground without any attachment, in the form of rugged truffle-like bodies, of the size of walnuts. Sometimes the bodies are piled together in strata of some inches in thickness, in consequence of their being easily rolled along by the wind. The most curious point in their history, however, is, that they are sometimes carried up by whirlwinds, and deposited after traversing the air for many miles; giving rise to histories of the miraculous descent of food. A few years since, in a time of great scarcity at Erzeroum, a shower of these Lichens fell most opportunely, to the great relief of the inhabitants; and other equally authenticated instances of a similar incident are on record. A pamphlet has been published by Dr. Arthaud to prove that this must have been the manna of the wilderness, with which the Israelites were fed; but, not to mention its miraculous origin, it does not at all answer to the description in the book of Exodus. Pallas informs us that another species, with very different habits, is eaten by the Kirghiz Tartars. It forms a crust on the soil and is mixed with *Nostoc*. Other species besides *Cetraria islandica* have been used in medicine, and some have found considerable reputation, as *Sticta pulmonacea* and *Peltidea canina*. The former owes much of its reputation to the resemblance of the under surface to that of a lung; while the virtues of the latter in hydrophobia are quite imaginary. *Cenomyce pyxidata* and its allies have been recommended for hooping-cough. *Sticta pulmonacea* is so bitter in Sweden, that it is sometimes used as a substitute for hops. *Alectoria Arabum* has the reputation of being sedative, and *Evernia vulpina* is said to be poisonous to wolves. *Evernia prunastri* was formerly used as a material for hair-powder, from its white colour, amylaceous nature, and supposed power of retaining odours. It has been observed by Dr. John, that Lichens which grow on the top of fir-trees contain more than an ordinary portion of oxyds of iron.* *Parmelia parietina* is still sold by the herbalists. It has been recommended in Germany as a substitute for Cinchona bark, and was used in other cases where astringents are necessary, as it had been previously by Haller and Willemet. It affords also a beautiful test for alkali, the yellow decoction assuming a beautiful red tint. *Cenomyce rangiferina* is a most important vegetable wherever rein-deer are kept, supplying a large portion of their food, and one which from its nature is as luxuriant in winter as in summer. The deer have only to scratch up the snow where it abounds, and they have at once an abundant and nutritive food, which has the advantage, when dried up by the long burning days of an arctic summer, of being restored at once to its suppleness on the first returning shower.

425. There is one economical purpose to which Lichens are applied—viz., dyeing; in which they are of some importance. While some, as *Parmelia parietina* and *Evernia vulpina*, yield colouring matter under the form of chrysophanic and vulpinic acids, others contain colouring principles, which, though without colour in themselves, afford beautiful tints when treated with alkalies. Yellows and browns are afforded by the two Lichens above-mentioned, and *Umbilicaria pustulata*,

* It is supposed by Schnedermann, that the red spots which are sometimes found at the base of *Cetraria islandica*, are due to the presence of cetrarate of iron. The brown discoloration is probably due to cetrarate of ammonia, arising from the cetraric acid imbibing ammonia from the air. Similar explanations may possibly be given of the discoloration so common in other lichens.

Sticta pulmonaria, and probably several other species; but these are of little comparative importance. The purple and blue are of much greater consequence, the former of which is obtained largely in this country under the name of Orchil and Cudbear; while the latter is manufactured in Holland under the name of Litmus. The kinds which are principally used are *Roccella tinctoria* and *fuciformis;* certain allied species or varieties of these Lichens; together with a few species which have a more depressed habit and pass under the name of moss. The Angola weed, however, *Roccella fuciformis*, is employed now almost exclusively, as being the best, and at the same time the most economical. The colouring matter is known under the name of Orchil. *Lecanora parella* was once largely gathered in Scotland, and the gathering, though a tedious process, afforded employment to many in the Highlands.* It is now obtained principally from Norway and Sweden, for the London market, the manufacture being principally in the hands of the English. The colouring matter which gives a purple tint to woollen yarn is known under the name of Cudbear, from the Christian name of the gentleman, Dr. Cuthbert Gordon, who first introduced it at Glasgow. It is, however, fugitive. In the preparation of Litmus, potash or soda is used, and by their use any Lichen which yields Orchil will produce Litmus. Litmus is of great importance, as affording one of the most delicate tests for acids, and is much used under the name of Blue Test Paper, which acquires a red tint by the slightest application of an acid. Other tests of less general use are afforded by these Lichens; and it is to be remembered that a variety of different substances, of different chemical characters, and economical importance, are obtained from them; a full description of which is of interest only to the chemist and manufacturer.

426. Dr. Lindsay has lately been calling the attention of the Botanical Society of Edinburgh to the importance of the

* A person could earn about fourteen shillings a week by collecting it. In some parts of North Wales it is particularly fine and abundant, and used to fetch about three-halfpence a pound.

subject. The true Orchil weed is becoming scarce in the localities which principally afford it, though there are many portions of the world which yield either that or other valuable species. When it is stated that specimens of *Roccella fuciformis* were exhibited at the Crystal Palace, from Ceylon, which were supposed to be worth £380 per ton, and of *Parmelia perlata* estimated at from £190 to £225, it may be imagined that the subject is worth consideration.*

427. †It was stated before, that the first traces of vegetation on exposed rocks are due to minute Algæ. This is true according to the received notions of the affinities of these minute bodies; but as some of them are certainly the early stage of Lichens, they must not be excluded. Lichens, indeed, in general need no soil into which to strike their roots, or at whose expense they may live, but are capable of growing and being propagated for indefinite periods where no other traces of vegetation appear; but some of the species, by their decay, afford a fitting mould for the development of mosses, and where these are once established Phænogams soon follow. This independence of soil is one cause, probably, of the very extensive distribution as regards species; for the genera and species of Lichens are more completely cosmopolitan than those of any other tribe of plants whatsoever. A large number of species seem to occur in almost every part of the world, as, for example, *Usnea barbata, Ramalina calicaris, Parmelia elegans, saxatilis, subfusca, Cladonia rangiferina* and *pyxidata, Lecidea geographica, Pertusaria communis, Verrucaria nitida, Thelotrema lepadinum, Biatora vernalis, Graphis scripta,* and *Collema tremelloides.* These plants are mentioned because they are well-known species, and also as

* A great deal of interesting matter of various kinds relative to Lichens, will be found in Dr. Lindsay's Popular History of British Lichens. Reeves, 1856. See also Report in Gard. Chron., Aug. 4, 1855.

† The Rev. Churchill Babington, who has a more intimate knowledge of Lichens in general, and more philosophical views on the subject than any British Botanist with whom I am acquainted, has kindly drawn up for me far the greater part of the remarks relative to the distribution of Lichens.

instances of the wide diffusion of the principal genera. In truth, it is very unsafe to prescribe absolute limits to the diffusion of the genera. Recent discoveries more and more tend to show that they have a far wider range than has generally been supposed. This remark will not, however, be made without attempting to prove it. The genus *Chiodecton*, first described by Acharius, in 1815, was supposed at first to be wholly tropical; but a species was found in 1824 in the Iles d'Hyères, and another more recently in Ireland by the late Dr. Taylor. The genus *Glyphis*, which was described by Acharius at the same time, from tropical species, is absent from the Lichenographia Europæa of Fries (1831); but a species has been collected in Portugal by Dr. Welwitsch, and in Ireland by Sir Thomas Gage. The *Glyphidei* contain a fair number of species (some of which are common) in tropical America, and eleven have been collected by M. Leprieur, in the neighbourhood of Cayenne alone. Again, if there be one feature peculiar to tropical Lichenology above another, it is the frequency of the strictly epiphyllous species, more especially of the genus *Strigula*. Yet Fries first included one (seemingly imperfect) species in his Lichenographia Europæa, found in Switzerland; and another was found in 1848 in this country, where it appears to be very common. An epiphyllous *Parmelia* has also been lately found in England, which is probably only a wanderer from its true tropical home. These three genera are still wanting in temperate and arctic North America. Conversely, it is certain that some genera which had only been found in the northern hemisphere, occur towards the extremity of the southern. If any one should be asked to select a genus abounding in Europe and the more northern America, but not occurring elsewhere, he would no doubt fix upon *Calicium*; but Mr. Colenso has lately gathered a species in New Zealand. Again, if any one large genus of Lichens is pre-eminently tropical, it is the genus *Trypethelium*. Fifteen *Trypetheliei* have been found near Cayenne alone. Not a species has yet been discovered in Europe or North (temperate and arctic) America; and we had never seen a well-marked species of the genus from any country south of the tropics, till Mr. Colenso found *T. madreporiforme* in New Zealand. An obscure species, however, of this genus (as it seems) occurs at the Cape of Good Hope (*T. bicolor*, Taylor). Another example is afforded by the genus *Myriangium*, Berk. and Mont. It was first found under two forms by Mr. Drummond, in Australia. One of these, on communication with Dr. Montagne, proved to be identical with a Lichen from Algiers and the south of France, and has since been found to ascend as far north as the Channel Islands. It occurs also in New Zealand; and a far handsomer species than either has been found in South Carolina by Dr. Curtis. With such facts as these before us, we cannot venture to do more than say positively that this or that genus is a characteristic of the Flora of this or that region, or that such and such genera scarcely reach such and such regions, and all our future remarks are to be understood with the limitations above indicated. We shall in the sequel point out the principal seats of the genera of Lichens according to their tribes, without descending to the species. The distribution of a large number of species has been worked out by Mr. Babington in Dr. Hooker's Flora of New Zealand, and that of some others in Seeman's Botany of the Herald, to which the reader is referred; he will also find a good deal of information made ready to hand by Eschweiler, respecting the distribution of the Brazilian Lichens in Martius' Flora of Brazil. We shall follow the arrangement of the Lichens given by Dr. Montagne in his Aperçu Morphologique de la Famille des Lichens, published in the Dict. Univ. d'Hist. Nat., Paris, 1846, which is based upon that of Fries, and which appears, upon the whole, the most satisfactory that has been proposed. Lichens are divided naturally into two divisions of very different statistical importance; in one of which the hymenial disc is ultimately open; in the other, on the contrary, remains permanently closed. The former of these, as displaying an hymenium like that of *Peziza*, may be considered the most perfect; the other approximates very closely to *Sphæria*.

LICHENALES.

ANGIOCARPEI.—Apothecia closed or nucleiferous.

- *Limboriei.*—Excipulum carbonaceous; aperture irregular.
- *Trypethelici.*—Excipula immersed in distinct pustules; nucleus deliquescent.
- *Verrucariei.* —Excipula scattered, carbonaceous; aperture punctiform; thallus crustaceous.
- *Endocarpei.*—Excipulum simple or double, at length ostiolate; thallus horizontal.
- *Sphærophorei.*—Excipulum at length ruptured above; thallus vertical, fruticulose.
- *Lichinei.*—Gelatinous.

GYMNOCARPEI.—Apothecia open.

- *Caliciei.*—Disc at length pulverulent.
- *Glyphidei.*—Disc irregular, coloured, at length exposed, immersed in warts of the thallus.
- *Graphidei.*—Disc elongated, simple or branched, with or without a proper excipulum.
- *Pyxinei.*—Disc orbicular; excipulum adnate to the horizontal foliaceous thallus.
- *Coccocarpei.*—Disc rounded, without any excipulum.
- *Collemacei.*—Thallus gelatinous.
- *Lecidinei.*—Disc naked from the beginning; excipulum present; thallus various.
- *Parmeliacei.*—Disc orbicular, surrounded by the thallus.
  - *a. Peltigeri.*—Disc at first veiled, bordered by the thallus; thallus foliaceous.
  - *b. Euparmeliacei.*—Disc at first closed, bordered by the horizontal centrifugal thallus.
  - *c. Usneacei.*—Disc at first naked; thallus for the most part vertical, without hypothallus.

I. ANGIOCARPEI, *Schrad.*

Apothecia closed, at length dispersing their sporidia by means of an irregular fissure or minute ostiolum; nucleus firm or deliquescent.

428. It is very doubtful, as said above, if any Lichens are truly sporophorous in their most perfect state. There may be sporiform fruit in addition to the sporidiiform; and if the bodies which occur occasionally on the tips of the asci be

reproductive, such a junction is not uncommon, without taking into account any pycnidiiform fruit. We shall have little hesitation, therefore, in cutting off, as autonomous plants, all such productions as *Pyrenotheæ*, in which no asci have at present been detected. They are, in fact, due to mere pycnidia of so many *Verrucariæ*.

1. Limboriei, *Fr.*

Excipulum carbonaceous, at length opening by means of an irregular pore. Thallus crustaceous, epiphyllous, originally sub-epidermic.

429. Omitting such plants as those mentioned in the preceding paragragh, we first encounter those species with a true crust, which, in some cases, approach near to Fungi, and are mostly parasitic on living leaves. It has been stated before, that such genera as *Strigula* are at first developed beneath the true cuticle; and it is to the close adherence of this that their lustre is sometimes due. The carbonaceous perithecia, for the most part, burst irregularly; and they are, in most cases, easily distinguishable from *Sphæria* by their crust, which is sometimes highly developed, and beautifully sculptured. The species are probably numerous, but at present they have not been sufficiently studied, and as the fronds vary greatly under different circumstances no correct estimate can be made of numbers, till the fructification has been extensively examined. The species are developed principally on the upper surface of thick tropical leaves, which suffer greatly, and soon lose all their beauty from their repeated attacks. It may be doubted whether all the genera which are associated by authors, are as nearly allied as they suppose. The analogy between *Strigula* and *Asterina* is very close, and both concur in choking up the pores of the leaves and preventing the admission of light to the tissues.

430. If the tribe be confined to *Strigula* and its allies, it must be considered as essentially tropical, with a few outlying species. In a few cases, where the patches are well defined, and there is no admixture of other Cryptogams, the appearance is neat and striking. *Limboria* is the typical genus of the tribe. I have had no opportunity of examining the struc-

ture of any species, but the figure of Eschweiler seems to indicate, from the linear arrangement of the sporidia, that there are asci. The perithecia open exactly in the same way as those of *Phacidium*, especially *P. Delta*, Kze. (Fig. 66, *b*), a species which is very abundant in Madeira on the leaves of laurels. The dehiscence in the other genera is much less regular, and it is very probable that in *Cliostomum*, in which the corrugated appearance is due to the contraction of the peridium, and dehiscence takes place eventually in the direction of these contractions, the spores are naked. *Gyrostomum*, Fr., is founded on *Lecidea scyphulifera*, Ach., a species from Sierra Leone, which appears to be truly ascigerous; but I have had no opportunity of examining any species. *Strigula Babingtonii*, Berk., which is common on leaves of

Fig. 80.

a. *Strigula nemathora.**

b. *Strigula Féei*, with section of perithecium, asci, paraphyses, and sporidia. From Ceylon. Communicated by Mr. Thwaites.

c. Cephaleuroid condition of some *Strigula*. From Caripi. Communicated by Mr. Spruce.

d. Paraphyses of a *Lecidea* allied to *L. sabuletorum*, bearing stylospores. From the late Mr. Gardiner.

All more or less magnified.

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* Mr. Babington considers *Strigula* as belonging to *Verrucariei*, but the epiphyllous subepidermic origin and irregular rupture seem to distinguish it.

evergreens in this country, connects the genus closely with *Asterina*. The other so-called European species are very obscure. An anamorphosis of many species frequently occurs, in which vertical threads tipped with large conidia are developed, a state which constitutes the genus *Cephaleurus*.

Fig. 81.

a. Cephaleuroid state of *Strigula Féei*. From Ceylon. Sent by Mr. Thwaites.

b. Asci and sporidia of *Abrothallus Welwitschii*. Communicated by Dr. Montagne. From Portugal.

c. Stylospores of *A. Smithii*. Communicated by Dr. Lindsay.

d. Sporidia and asci of a *Trypethelium*. Gathered on the coast of Guinea by M. Jardin.

2. TRYPETHELIEI, *Fr.*

Crust sprinkled with pustules; pustules consisting of a heterogeneous, often coloured, stroma, circumscribed by a cortical excipulum, and containing imbedded in its substance one or more ostiolate perithecia.

431. These species are to *Verrucaria*, what *Hypoxylon* is to *Sphæria*. There is in the more typical *Verrucariæ*, a distinct crust, as in *Trypethelium;* but in the one case the perithecia are scattered, or at the most crowded into little groups; whereas in *Trypethelium* they are immersed in a common cellular mass, like the stroma of *Hypoxylon*. This mass arises from the medullary substance with which it often agrees in colour,

though sometimes more highly oxydised, and it is, in fact, the elevation of portions of the crust into distinct pustular bodies, which forms the grand distinction. The perithecia have often a distinct ostiolum projecting beyond the outer surface, and the resemblance to *Hypoxylon* is sometimes so great as to make an error almost excusable in a young botanist; as, for instance, in *Trypethelium Sprengelii*. The asci are well deve-

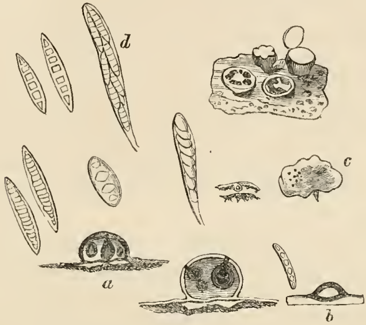

Fig. 82.

a. Pustules of *Trypethelium Sprengelii,* with sporidia. Communicated from Ceylon by Mr. Thwaites. The endochromes of the sporidia are irregularly imbricated. Above the left hand pustule is a separate sporidium of *T. cruentum.* Sent from S. Carolina by Rev. M. A. Curtis.

b. Section of perithecium of *Verrucaria variolosa,* with sporidium. From a Cayenne specimen sent by Dr. Montagne.

c. Thallus of *Endocarpon lachneum,* with vertical section and fruit. Moug. and Nest., 442.

d. Stegobolus Berkeleianus, Mont. A portion of the plant, with ascus and two sporidia. Cuming Phil., No. 2185.

All more or less magnified.

loped, and the sporidia often very beautiful and complicated. It appears to me that this mode of viewing the structure is more simple, than considering the common mass in which the perithecia are immersed an external perithecium. It is not exactly homologous with the stroma of *Hypoxylon,* but it is certainly analogous. The external coat is a mere modification of the cortical stratum, though often somewhat differently coloured, as the inner substance is of the medullary stratum. The other genera belonging to the group are of comparatively small importance. Of these, *Porodothion*, Fr., is distinguished by the absence of true perithecia, insomuch that it is exactly analogous with *Dothidea*. *Sphæromphale* has coloured solitary perithecia, and approaches very near to *Verrucaria*. The species are European, and live on rocks. The coloured perithecia prevent their being considered simple *Trypethelia*. *Astrothelium* has a multilocular pustule from the confluence of the perithecia, which have a common ostiolum, analogous with *Cytispora*. *Trypetheliei* are very nearly confined to the tropics, but there are one or two species in the southern hemisphere, and *Trypethelium cruentum* has been sent to me from South Carolina, on the bark of *Ilex opaca*.

3. VERRUCARIEI, *Fr.*

Excipulum closed, resembling the perithecium of a *Sphæria*, discharging the sporidia by a central ostiolum or pore. Thallus crustaceous.

432. *Verrucariei* are distinguished by their simple perithecia, which are not immersed in any distinct pustule of the crust. In *Pyrenastrum*, the perithecia are crowded round a common column very much after the fashion of a circinating *Sphæria*, and in other cases they are slightly crowded; but the distinction holds generally good. For the most part, the walls of the perithecia are black. The thallus, when present, is crustaceous; but in some cases it is so thin, and confluent with the substance of the matrix, as to be inseparable and almost indistinguishable. The sporidia are in general far less complicated than in the preceding group. The species often occur on the living bark of trees, but they are found also on mould, or upon the hardest rocks. One species, at least, inhabits the smooth stones of running streams. As remarked above, the resemblance to Fungi is very close, and this is not confined altogether to the simpler species. A Cryptogam resembling *Pyrenastrum*, occurs on the smooth bark of oaks in Northamptonshire, and has been found also by Mr. Spruce

in the Pyrenees. I have published it as *Sphæria parmentaria*, but perhaps it ought rather to be considered a *Pyrenastrum* (= Parmentaria). Indeed, had not *Pyrenastrum* been a tropical genus, there would, probably, have been no hesitation on the subject. In some of the tropical species the perithecia are very highly developed and of considerable size, but they vary greatly in the same individual. Sometimes, however, this is deceptive; for, as they are often spread out at the base, as in *V. variolosa* (Fig. 82, *b*), when the cuticle of the plant or the crust wears off entirely, more of the walls are exposed, and they appear, in consequence, much larger than before. The genus *Verrucaria* is universally diffused, but a very large number of the species are peculiar to the barks of tropical trees, and in such the perithecia attain their greatest size. Tulasne figures curved spermatia like the spores of some *Septoria* in *Verrucaria muralis*.

4. Endocarpei.

Excipulum pale, single or double, at length piercing the horizontal thallus by a distinct ostiolum.

433. The species of this group are distinguished by their perithecia being included in the substance of the thallus, and never carbonised, as in true *Verrucariæ*. The crust is, for the most part, foliaceous, though there are species which depart from the more typical forms in this respect. The distinct ostiolum and gelatinous nucleus distinguish them from *Parmeliacei*, with which they agree in some respects. The foliaceous frond assumes the appearance of *Hepaticæ* or *Cyphella*, but it is mere analogy without the slightest relation. In *Endocarpon* (Fig. 82, *c*), the thallus is, for the most part, peltate. The species grow on moss, exposed earth, and stones, while some are frequently or periodically submerged, and during the greater part of their life, when not actually beneath the water, constantly moist with its spray. The nucleus is, for the most part, coloured, and the frond varies much in hue. In *Sagedia* the perithecia at length assume a darker tinge, so that we have the habit of *Endocarpon*, with somewhat of the character of *Verrucaria*, though they are never really carbonaceous. In *Pertusaria* we have a distinct crust, with the peri-

thecia sunk in wartlike processes, so as to make an approach to *Trypethelium*. The well-known Lichens which pass under the name of *Variolaria* are mere degenerations of its species. *Porina* differs from *Pertusaria*, in having only a single perithecium in each pustule.* *Stegobolus*, Mont. (Fig. 82, *d*), founded upon one of the Lichens collected by Cuming, in the Philippine islands, is remarkable for throwing off a little lid from the top of the swellings formed by the perithecia. When this has fallen, there is a white chalky disc, which gradually breaks up together with the upper part of the perithecium, exposing the hymenium. *Thelotrema* has the disc at length naked, surrounded like *Stictis* by the lacerated margin of the true perithecium, but there is no displacement of a distinct lid, as in the former case. It is, in fact, exactly analogous to *Limboria*, to which genus it might be referred, save for its colourless perithecium. The genera are, for the most part, cosmopolitan; but a great number of the crustaceous species are peculiar to the tropics. Linear subtruncate spermatia are figured by Tulasne, in *Endocarpon sinopicum*, and more minute and subfusiform in *Pertusaria communis*, which is remarkarble for the numerous strata in the epispore. Spermatia of a subelliptic form, are also figured in *E. miniatum* and *hepaticum*. The sporophores in *Pertusaria* are cylindrical; in *Endocarpon* moniliform, cellular, or short and oblong. *E. sinopicum*, moreover, has myriads of sporidia; but, probably, another form of sporidia will eventually be found similar to that of *E. miniatum* (Fig. 82, *a*), or *E. lachneum* (Fig. 81, *c*).

5. SPHÆROPHOREI, *Fr.*

Excipulum pale, not distinct from the stroma, at first entire, then irregular, ruptured above. Thallus vertical, fruticulose.

434. The branched and erect habit of the thallus of the Lichens which belong to this group, induces a corresponding change in the character of the fruit. The walls of the apothecia are scarcely distinct from the stroma. Were the thallus reduced to a thin frond we should have nuclei scattered up and

* *Ascidium*, Mont., differs in the same way from *Trypethelium*.

down without any very distinct pustule; we should, in fact, have an *Endocarpon.* The terminal fruit on the numerous branches of *Sphærophoron* (Fig. 83, *b*) is first indicated by a swelling, and in process of time the outer bark bursts and exposes the contents of the perithecium, which consist of asci, and paraphyses seated on a central columella. It has been supposed that the sporidia were connected together in moniliform chains; but there is no difference between them and the

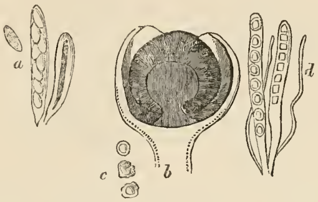

Fig. 83.

a. Asci and sporidia of *Endocarpon miniatum* (Moug. and Nest. 57).
b. Vertical section of perithecium of *Sphærophoron Coralloides* (Moug. and Nest. 262).
c. Sporidia of ditto.
d. Asci and paraphyses.
All more or less magnified.

sporidia of normal Lichens. The sporidia are beautiful objects under the microscope, on account of their blue tint, and they are singular amongst Lichens, with but few exceptions, on account of their spherical form, which is, however, often masked by the rough epispore. The mode in which the mass of spores breaks up is somewhat like that of *Calicium*, but they are more closely compacted. They occur on trees and stones, and are the great ornament of many a scattered boulder on the mountains. *Siphula* differs in the hymenium, never cracking up into powdery particles, but is expanded and at length deciduous; while *Acroscyphus*, which is much coarser, with the habit of a branched *Clavaria*, opens by a pore only, has a thin expanded hymenium and bipartite sporidia, like some species of *Calicium.* It differs, in fact, more in habit than in character, from *Siphula.** The spermatia of *Sph. compressum* are very minute and oblong. In *Acroscyphus* they are of nearly the same form, but coarser. *Sphærophoron* occurs in the cold and temperate regions of both hemispheres, but seems to be very rare within the tropics. The southern hemisphere has a few fine endemic species. *Acroscyphus* occurs in Peru. One of the most curious genera perhaps of *Sphærophorei* is the Cayenne genus *Ozocladium* (Fig. 85, *a*). The main thallus is branched and beset with a single row of imbricating, scale-like apothecia, proliferous at their upper margin, so as to present a moniliform appearance. Each apothecium is at first closed, but the top soon bursts like a veil, disclosing a disc consisting of linear asci, filled with a single row of numerous pale hyaline sporidia, like some species of *Hypocrea.*

6. Lichinei, *Mont.*

Thallus gelatinous, erect, or horizontal; gonidia forming moniliform chains or fissiparous; excipulum of the same nature as the thallus.

435. The difference of substance between the gelatinous Collemals, and the more or less rigid Lichens, is the only character which separates them; unless it be the peculiar modes of arrangement assumed by the gonidia. I cannot, therefore, assent to this distinction, though there are two distinct groups, belonging respectively to the gymnocarpous and angiocarpous type. *Lichina* has the habit of *Sphærophorei,* and differs principally in its substance. Its habitat on exposed marine rocks, often dripping with salt water, and as suddenly dried up, requires in it some element very patient of change. There is no true perithecium, and the sporidia are very different from those of *Sphærophoron,* being quite colourless, and resembling more those of Fungi; indeed, but for the gonidia it must be associated with them. *Paulia* assumes the foliaceous form, and is analogous to *Endocarpon.*

* The old perithecium, when divided, resembles very closely the cup of some acorn. The orifice is circular and quite even, the inner surface perfectly smooth, with an orbicular darker disc at the base.

The gonidia in this genus, as also in *Synalyssa,* which belongs to another tribe, are totally different from those of *Lichina,* and approach closely the type of *Palmella,* figured at p. 118.* *Mastodia* has the habit and form of an *Ulva,* but the perithecia are those of *Lichinei.* *Ephebe* also finds its true place here, after being shifted about in various directions. The frond is essentially that of an Alga, and is destitute apparently of

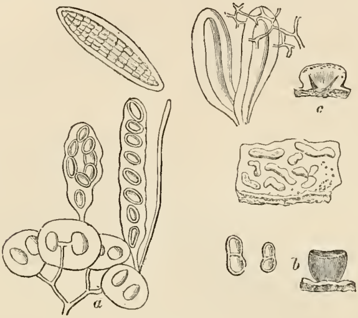

Fig. 84.

a. Paulia perforata, Mont. Gonidia and asci, from a specimen communicated by Dr. Montagne. Magnified.

b. Calicium tympanellum. Perithecium and sporidia from Moug. and Nest., No. 859. Magnified.

c. Graphis Leprevostei, Mont., representing a portion of the natural size; a young fertile swelling cut through, showing the excipulum; young asci from the same, with branched tissue, in which they are involved, and a sporidium. All more or less magnified. From a Cuban specimen, from Dr. Montagne.

true gonidia. Some species, in fact, so closely resemble *Scirosiphon,* that without the fruit they could never be separated. One or two filiform species of doubtful affinity yet remain, especially *Cystocoleus;* but without true fruit it is impossible to speak with certainty. Tulasne finds, in *Lichina confinis,* spermatogonia on the same branches with the perithecia, and

* See Thwaites, in Ann. of Nat. Hist., vol. 3, p. 219.

beneath them. Their nucleus is compound and bears elliptic spermatia. In *Lichina pygmæa*, the spermatogonia are seated on the perithecia. Their nucleus is simple; in both the spores are more or less united into moniliform series. The species are widely dispersed, but luxuriate in the tropics. *Paulia* is a genus of the southern hemisphere, as is also *Mastodia*, but of far colder localities. *Ephebe* is, I believe, confined to the northern hemisphere. *Lichina* occurs in New Zealand.

II. Gymnocarpei, *Schrad.*

Hymenium or thalamium at length exposed, disciform, with or without a distinct excipulum ; tips of paraphyses often charred by exposure.

436. We have considered, first, those Lichens in which the fructification is formed more or less after the fashion of *Sphæria;* whether exposed or scattered within the thallus, or included in certain swollen and privileged portions of it. We have now to proceed to those in which the disc is essentially open, and not merely exposed by a rupture of the cellular tissues of the Lichen. Something like such an expansion was noticed under *Siphula ;* but it is very far from the structure of the group now to be described. This order includes the great mass of Lichens, in every possible variety of form and habit ; the essential chararacters, however, still remain the same, and the group so natural that they run into each other, so as to leave no very striking distinctions.

1. Caliciei, *Fr.*

Thallus horizontal ; hymenium at first closed by a veil, then exposed, contained in a pedicelliform or sessile excipulum.

437. We have here a group differing singularly in habit from the rest. The crust is ill-developed in general, but the striking characters consist in the distinctly stipitate or more rarely sessile excipula, looking like little flat-headed pins stuck into the crust, the hymenium of which is covered by a delicate veil, which at length vanishes, and exposes the pulverulent mass of spores, making an approach, as regards technical characters, to *Sphærophoron.* The peduncle is very much of the same substance as the immediate supporter of the hymenium ; and totally different from the crust, though proceeding from

the medullary stratum, and must, in fact, be considered as part of the excipulum. The sporidia often adhere together like little necklaces, but they are at first contained in distinct asci. They are either simple or uniseptate, orbicular or sub-elliptic. Far the greater part of the species grow on wood ; but one or two inhabit rocks. *Calicium turbinatum* occurs on the crust of *Pertusaria,* and has been supposed by Wahlenberg to be a degeneration of its ostiola. This notion, however ingenious, is contradicted by the presence of proper fruit, totally different from that of the matrix. The production ought probably to be separated, under the name of *Sphinctrina,* and has almost as much right to be placed amongst fungi as lichens. One species, closely allied, is found on the masses of gum which flow from *Cerasus serotinus* in South Carolina. *Trachylia* has scabrous, horny, immarginate excipula, resembling in form those of some *Lecidea,* but differing in the pulverulent fruit, while *Coniocybe,* which approaches closely to Fungi, has a proper excipulum, destitute of any distinct margin, and splitting above. In *Calicium inquinans* the sporidia are so loosely attached that they make a sooty impression upon the fingers when they are touched. Tulasne figures curved spermatia in *C. turbinatum.* The species are almost wholly confined to Europe and North America, especially the cooler parts. One species has been found in New Zealand.

2. GLYPHIDEI, *Fr.*

Disc coloured, at first nestling in the medullary substance of the crustaceous thallus, then exposed and surrounded by the thallus, which is swollen into pustules. Excipulum mostly absent or spurious.

438. This tribe is exactly analogous to *Trypetheliei.* The thallus is raised here and there into pustules, or distinct expansions, in which the open discs are set like the stones of a mosaic. The expanded surface is often coloured and irregular, and the species have sometimes a fungoid aspect. There is, in point of fact, no true border to the disc, the perithecium being reduced to a thick conical base, from which proceed immediately the asci and paraphyses ; each individual hymenium being surrounded by the intervening medullary matter, injected

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as it were into the interstices. In some species, as *Chiodecton monostichum*, there are scarcely any distinct fructifying spots, the whole surface being productive. The spermatogonia of *Chiodecton* are figured by Tulasne, in the form of little scattered perithecia, which produce filiform, curved spermatia.

439. The typical genus *Glyphis** is distinguished from *Chiodecton* by something like an excipulum extending up the sides of the hymenium. In *Medusula* we have the elongated form of *Hysterium*, to which there is an approach also in some species of *Glyphis*, accompanied by a radiating disposition, which is repeated in *Actinoglyphis*, Mont. This is, however, distinguished by a double row of partial excipula along each disc. *Byssophytum* is also placed in this tribe by Montagne. The apothecia of this curious plant are discoid and bordered by the thallus, destitute of any proper excipulum, and enclosing a byssoid parenchyma which gives rise to coloured pulveraceous spores. This abnormal genus, of which I possess by the kindness of Dr Montagne the Tahiti species *B. sulfureum*, appears to me scarcely autonomous. A Lichen without asci would be a complete anomaly, when productions like *Pyrenothea* are excluded. The species of *Glyphidei* are almost wholly tropical, though one or two species occur rarely in Europe. *Chiodecton myrticola* ascends as high as Ireland, where it was discovered by Dr. Taylor. The coloured disc is characteristic of most of the species, but the tint is sometimes obscured by a pulverulent coat, or the surface blackened by age.

3. Graphidei, *Fr.*

Disc linear, simple or branched. Excipulum carbonaceous, various, superior, or lateral, sometimes absent.

440. Exactly analogous to *Hysterium* and its allied genera, the genera of this group afford a large mass of the truly cortical species of Gymnocarpous, as the *Verrucariæ* do amongst the Angiocarpous Lichens. A large number of the species are readily referred to this tribe, being quite as perfect resemblances of letters as the mysterious marks upon the tree described by Huc and Gabet, the counterpart of which was

* The names of *Glyphis* and *Chiodecton* are transposed in Eschweiler's plate, so that the latter seems to have the more perfect organization.

discovered by Hooker and Thomson, in Khasya, on the leaves of a species of *Symplocos.** In most genera the individual perithecia are much elongated, and often pointed at either end, and when these are parallel, or placed at different angles to each other, they afford groups very similar to those of Chinese or Japanese letters. The characters on which the different genera depend, are founded principally on the nature of the perithecium, which is more or less developed according to circumstances, till in *Arthonia*, properly so called, for there are many spurious species, it vanishes almost entirely. In a few instances the linear or branched nature of the perithecia is lost, and they resemble *Hysterium* (Fig. 66, *a*). Sometimes the perithecium is entirely confined to the base, sometimes it forms a lateral wall all round, being deficient above and below, and sometimes it is completely restricted to the upper surface; and, according to circumstances, the disc is more or less fully exposed and distinct from the surrounding tissue.

Tulasne has figured in *Opegrapha* minute scattered spermatogonia, sunk in the substance of the crust, with linear moderately long spermatia. A few species of *Graphidei* occur in the frigid and temperate zones of both hemispheres; but by far the greater part are found in tropical America, which has several genera or subgenera peculiar to itself. It is remarkable that only one *Graphis*, and not a single *Opegrapha*, has yet been found in New Zealand. *Sclerophyton*† is worth mention because of its elliptico-linear apothecia, with their coloured disc, being disposed in a single row on linear elevations of the crust, so that it answers to *Trypethelium*.

4. PYXINEI, *Fr.*

Disc orbicular. Excipulum distinct from the thallus, at first closed, superficial. Thallus horizontal, foliaceous, for the most part fixed by the centre.

441. This is one of the most singular groups of Lichens, both as regards the superficial fruit and the curious convolutions presented by the hymenium of many of the species. The

* Gardeners' Chronicle, 1854, p. 217.

† Montagne, in Ann. d. Sc. Nat., sér. 3, vol. 16, tab. 16.

fruit is at first closed, and in *Gyrophora* the disc is in a manner proliferous, and produces a number of partial discs on the original hymenial surface. As in other cases, the cells from whence the asci spring belong to the medullary stratum ; the border, on the contrary, to the cortical. The thallus is always foliaceous, and more or less peltate, though becoming extremely dry and brittle when exposed to drought. Several of the species have tufts of strong rootlets, by which the frond is attached more firmly to the rock, and some have deep pits, with which swellings in the upper surface correspond, from whence they have received, in the country where they most abound, the popular name of Tripe de Roche. They afford, however, at best, a very poor kind of food, and, in fact, are so apt to disagree that they are quite ineligible. One fine species exceeds sometimes a foot in breadth, and many of them are rather striking forms. The convoluted perithecia are analogous to *Glonium*, to a small patch of which they bear a close resemblance. Indeed, though there are occasionally orbicular shields, their affinity is rather with *Graphis* than with *Lecidea*. *Umbilicaria* is a *Gyrophora* without the convolute discs. *Pyxine*, Fr., is distinguished by its Parmelioid thallus, orbicular perithecia, opening by a circular aperture, and waxy disc. The sporidia vary considerably in size and appearance. In *Umbilicaria pustulata* they call to mind those of *Hysterium elongatum*, but are more complicated and larger, while in *Gyrophora proboscidea* they are very small, with a smooth epispore. In both, Tulasne finds minute oblong or linear spermatia, springing from the point of junction of the cells, which compose the moniliform threads, which line the cavity of the spermatogonia. The genera *Gyrophora* and *Umbilicaria* have their principal seat in arctic Europe and America, where they abound under various forms. Species also occur in temperate Europe and America, and in alpine tropical America, especially in Peru and in the Himalaya mountains, mostly at high elevations. They are exceedingly rare in the temperate and frigid regions of the south. One or two species are found at the Cape, and another in the Falkland islands. *Omphalodium*, Meyer (Sticta Hottentotta), which is remarkable for its hispid apothecia, occurs at the Cape of Good Hope. *Pyxine* requires a warm temperature.

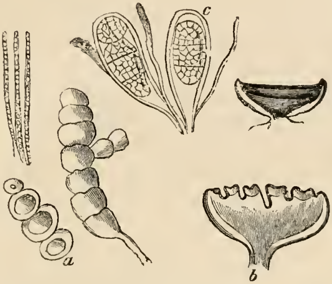

Fig. 85.

a. Ozocladium Leprieurii, Mont., from above and below with asci. Magnified. Communicated by Dr. Montagne.

b. Section of apothecium of *Gyrophora cylindrica*, Moug. and Nest., No. 59.

c. Ditto of *Umbilicaria pustulata*, with asci and paraphyses.* Moug. and Nest., No. 60. All more or less magnified.

5. COCCOCARPEI, *Mont.*

Disc expanded, orbicular, springing immediately from the medullary stratum, without any excipulum.

442. In this small group there is either no excipulum at all, or one confounded with the sparing thallus. In some cases the whole plant is little more than a mass of fructification, parasitic upon other Lichens, and continuous with their substance, like true parasites. They are parasitic on the crust, hymenium, &c., and seem to be as truly Lichens as the plants at whose expense they live. Several species have been found in England, which were long overlooked as mere stains, or regarded as obscure ill-developed fruit. The *Abrothallus*, however, of *Sticta fuliginosa* is possessed of some beauty, and is an important addition to our Lichens. Though consisting almost entirely of fruit, *Abrothallus* and *Scutula* produce pycnidia,

* I find one or more horizontal divisions in the sporidia, and sometimes a second imperfect sporidium in the same ascus.

while *Phacopsis* and *Celidium* bear spermatogonia. These parasitic genera, however, are not the more typical forms of the group, but the genus *Coccocarpia*, which comprises certain species separated from *Lecidea*, and which differ from that genus in the total absence of any excipulum. The nucleus is, according to Montagne,* at first inclosed in the medullary stratum, and at length erumpent. The thallus is between membranaceous and tremelloid, and remarkably tomentose beneath. The fruit of Collemals at once distinguishes them. It is to be observed that Tulasne (Mém., p. 127) considers the apothecia even of this genus parasitic, but he is not borne out by other authors. Their asci and sporidia (Fig. 81, *b*) resemble those of some minute *Sphæriæ*. *Coccocarpia* occurs in tropical America, the Philippines, and other islands of the Pacific and Atlantic, but not in Europe or temperate North America, unless *Endocarpon pulchellum* be really a *Coccocarpia*, as seems most probable. The parasitic genera occur in most parts of Europe and of North America, extending as far southward as central America, but not apparently in the southern temperate zone.

6. COLLEMACEI, *Fr.*

Frond gelatinous, containing moniliform threads of minute gonidia, or large ones arising by fissiparous division. Fruit apothecioid.

443. If *Coccocarpia* be indeed autonomous, we have an easy transition through that genus to Collemals; at any rate, if they are to be excluded from Lichens, *Hydnum gelatinosum* might as justly be excluded from the genus in which every one is content that it should remain, or *Tremellini* from Fungi. They are in all essential points Lichens, and to remove them is only to draw off the attention from generals to particulars. In most species of true *Collema*, there is less distinction of substance than in other Lichens, the whole seeming to consist of medullary tissue, confused with the cortical and gonimic; but in *C. chloromelum* and *bullatum* (Fig. 79, *c*)† there is a dis-

* Ann. d. Sc. Nat., sér. 2, v. 16, p. 122.

† This is not the same plant with *Leptogium bullatum*, Mont., but that which is figured by Swartz.

tinct epidermal cellular coat. *Collema* is thus closely connected with *Leptogium*, which is further distinguished by its marginate disc. The gonidia differ very much from those of other Lichens. In *Collema* and its closer allies, they are minute and arranged in moniliform rows; but in *Synalyssa* they resemble those of *Paulia* (Fig. 84, *a*), arising from the fissiparous division of each gonidium, accompanied by a bifurcation of the supporting thread; while in *Omphalaria* (Fig. 86, *e*, *f*) their generation resembles that of *Hæmatococcus*. The fact was first noticed, I believe, by Montagne, under

Fig. 86.

a. Stylospores of *Abrothallus Smithii*, Tul. From specimens gathered at Craigie Hill by Dr. Lindsay.

b. Synalyssa vulgaris. From specimens gathered at Bristol by Mr. Thwaites. A portion of the plant with its fastigiate fruit and palmelloid, gonidia one of which is represented more highly magnified in the act of division.

c. Asci, sporidia, and paraphyses of the same.

d. Hæmatococcoid excrescences which roughen the thallus. These are tinged with red.

e. Hæmatococcoid gonidia of *Omphalaria nummularia*, Mont. From an Algerian specimen given to me by Dr. Montagne. The upper cell is darker than the rest, being near the surface.

f. Filaments of medullary tissue, forming meshes as in *Omphalaria Girardi*, two cells of the cuticle, and ascus with sporidia and paraphyses.

All more or less magnified.

Omphalaria Girardi, in the Flora of Algiers, tab. 18. Something of the same kind is figured in the same work in *Endocarpon Dufourei.* It is therefore very desirable that an accurate comparison should be made, as it may throw further light on their affinities. I have unfortunately not the proper materials at hand to work the matter out.

444. A portion of the Collemals have been noticed under *Lichinei;* and to the genera there noticed *Obryzum* may be added, on account of its conceptacular fruit. *Synalyssa* makes a near approach to *Lichinei* in this respect, as it does also in habit, but the disc is ultimately well opened. The same may be said of the curious genus *Myriangium.* In the two original species the disc is mostly veiled; but in *M. Curtisii,* Berk. and Mont., which is far the finest, it is as open as in any *Collema* or *Leptogium.* The cells in which the asci are contained may be compared with the arrangement of the asci in *Graphis Leprevostii* (Fig. 84, *c*). *Myxopuntia,* Mont., approaches very near to *Collema Schraderi,* differing slightly in the construction of the thallus, and is remarkable for the opuntioid constriction of the subfastigiate branches. The genus *Collema,* including *Leptogium,* is universal, and many of its species are very widely diffused. *Myriangium* occurs under the same species in the south of Europe, extending as high as the Channel Islands, and crossing the Mediterranean to Africa, and on the Swan River in Australia. *Myxopuntia* has been found only in northern Africa, where *Omphalaria* produces two species, a third occurring on the rocks of cataracts amongst the Vosges mountains.

7. Lecidinei, *Fr.*

Disc contained in a proper excipulum, open from the beginning, and in age frequently obliterated; thallus various.

445. We have here, again, a group containing very numerous species, and differing from each other extremely in habit. Many are amongst the most obscure of Lichens, adhering so closely to their matrix that they cannot be separated from it without destruction; while others are amongst the more noble forms, presenting erect branched fronds, often clothed with foliaceous scales, and of highly beautiful colours. Their dis-

tinctive character consists in their orbicular disc, contained in a distinct excipulum, which is open from the earliest stage of growth, and frequently becomes obliterated by age, in consequence of the centrifugal development of that part of the medullary stratum from whence the hymenium is formed. The disc in consequence becomes convex and capitate, assuming the same form as that of *Helotium* amongst the *Pezizæ.* This transformation sometimes takes place in the most typical genera, as in *Lecidea,* and is quite normal amongst the nobler species of the group. There is a distinct and regular series, from *Lecidea* upwards. The crust in that genus is always crustaceous, and often forms merely a thin, close, adherent, fibrous stratum on the hardest flint or quartz. As said above, however, though the margin is well developed at first, it is at length frequently obliterated, so as to conceal from the naked eye the character of the genus. In some species of the tribe, the sporidia are highly developed, as in the New Zealand *Biatora marginiflexa* (Fig. 79, *b*), where they attain a diameter of $\frac{1}{200}$ of an inch. *Biatora* differs but slightly from *Lecidea;* but the convexity of the discs, which is accidental in the latter, is normal in the former. In *Lecidea* the disc is of the same colour, with the border; in *Biatora,* different. The thallus is more inclined to put off the crustaceous form, and a ready link of transition is prepared by it for *Bæomyces.* In that genus we have the first indication of a stem to the apothecia, or, as it is called, a podetium. Here it is terminated by a single convex and often distorted disc of bright colours, as rose, chesnut, &c. The rose-coloured fungoid hymenium of *B. roseus* and *ericetorum* are striking ornaments of many a little heathy bank, overshadowed by projecting heath, or other fine-leaved Phænogams. The thallus is more decidedly foliaceous in *Cladonia* (Fig. 18, *b*), producing free, scale-like fronds, from the midst of which spring cylindrical, or cup-shaped podetia, which are themselves sprinkled with leaves. The margins of the cups, or the tips of the branches bear an abundant crop of convex, irregular, brown, or deep red discs, which are often as bright as sealing-wax. In some cases, where the podetia are strongly branched, the tips alone are fertile and the discs are extremely small and obscure. One of the most beautiful forms is presented by the antarctic *Cenomyce reticulata* (Fig. 19), the podetia of which are elegantly reticulated, the meshes being traversed by delicate fibres so as to present the most charming effect. The discs, as in most cases where the thallus is so highly developed, are small and unattractive. *Stereocaulon* replaces *Cladonia* on exposed rocks, though the latter genus is by no means completely excluded any more than *Stereocaulon* is confined strictly to rocks. The podetia are here again strongly developed, and rough with minute processes ; and the apothecia have a distinct margin without that constant tendency to become distorted, which is so common in *Cladonia.*

446. Some of the minuter forms occur on tropical leaves, resembling closely certain species of *Stictis.* One of the most curious of these is *Sporopodium* * (Fig. 87, *a*), in consequence of the size of the single sporidium, which is formed from the upper part only of the protoplasm of the asci, the lower part remaining barren, and forming, as it were, a little peduncle to the sporidium, in the style of the Phænogamous *Podospermum.* Some of the exotic epiphyllous Lichens, consisting of a thin crust and upright threads, referred to two or three genera by Fée, as *Melanoplaca,* appear so abnormal, that I am inclined to consider them as imperfect or altered conditions of other Lichens. Septate conidia have been found in at least one species, but this is not inconsistent with the view just stated. It remains to notice here the genus *Cœnogonium,* which is allied to *Biatora,* though differing so greatly in the floccose tissue, the cortical being entirely suppressed. I am the rather inclined to think that its true affinities are here, because I possess a production, gathered in Switzerland, consisting of the apothecia of *Biatora,* and a crust composed of erect threads like those of *Chroolepus,* a confirmation of my notion that that genus, like *Cephaleurus,* may be a mere anamorphosis of the crust of Lichens. The genera are for the most part ubiquitous, as are a great many of the species also. *Lecidea*

* Mont. in Ann. d. Sc. Nat., sér. 3, vol. 16, p. 54.

is, perhaps, as patient of cold as any Lichen occurring in the extreme points of vegetation, both in the arctic and antarctic regions, and by no means confined to them. The black-fruited *Cladoniæ* belong to the Australian regions, and this genus, whose species on the whole are remarkably cosmopolitan, has a few very fine endemic species within the American tropics. Spermatogonia have been described by Tulasne in most of the genera.

8. PARMELIACEI, *Fr.*

Disc orbicular, or reniform, persistent (not deliquescent); bordered by the thallus.

447. The highest forms of which, apparently, Lichens are capable, are contained in this division; which, like most of the more typical groups, abounds in species. The hymenium is here surrounded by the edge of the thallus, without any proper excipulum. The tribe contains three very distinct groups, separated from each other by general habit and by technical characters; a large portion of our more widely diffused Lichens, whether growing on the ground, attached to rocks or trees, belong to it, and it contains many of the more useful productions of the order. Some of them abound to such a degree as to mask almost completely the trees on which they grow; others form patches a foot, or even many feet, wide,* on rocks; while localities almost constantly moist with salt spray are not exempt. It is amongst these that we find the more valuable species. In two of the groups the thallus is horizontal, and often foliaceous; in the third it is vertical and frequently branched.

a. PELTIGERI, *Mont.*

Apothecia at first veiled. Thallus horizontal.

* Some of the large patches of *Parmelia*, which occur on rocks, are of very great age. Patches of such Lichens as *Lecidea geographica* probably date from almost fabulous periods, and even small patches are often of considerable age. I have myself watched individuals for twenty-five years, which are now much in the same condition as they were when they first attracted my notice. Plants which endure without injury such extremes of temperature and conditions of the Hygrometer, would seem, *à priori*, to be likely to have great powers of longevity.

448. The first sub-tribe consists of the Lichens to which Montagne has given the name of *Peltigeri*, from their target-like discs, which are either orbicular or reniform, and at first concealed by a veil, the fragments of which often remain attached to the margin. They are frequently terrestrial species, and present beautiful expanded fronds. The true *Peltigeri* are remarkable for the venose appearance of the under surface, which is attached to the ground by numerous white or pale strigose hairs. The fruit is marginal and sometimes elongated, so as to give the frond a digitate aspect. The species are closely allied, and are well known to most observers of natural objects, from the pretty manner in which they adorn exposed hillocks, or the tops of earthen walls. They are often studded with a little red fungus, which adds greatly to their beauty.

449. *Nephroma* is distinguished by its reniform, marginal, hypophyllous discs, and frequently grows on the trunks of trees in shady woods, while *Solorina* has the fruit scattered over the frond, and often forms deep depressions. The under side of one species is of the most beautiful yellow, and is highly striking. In *Solorina saccata* the fruit is at first superficial; but a number of fibres are formed on the under side, penetrating the soil and drawing down the disc beneath the general surface. In *Solorina crocea* there are veins on the under surface, as in *Peltigera venosa*, but no fibres; and as no rootlets are sent out from the base of the disc, they remain superficial. The genera, are, however, closely allied to each other, and are comprehended in one by Fries and Endlicher.

450. The sporidia of *Solorina saccata* are uniseptate and granulated, resembling some *Puccinia;* the growth of *Peltigera polydactyla*, from the mycelium, is beautifully traced through every stage of growth by Tulasne. Little excrescences are first formed on the threads which, on the division of their endochrome, at length give rise to distinct fronds. The spermatia of *Peltigera canina* and *polydactyla* are obovate and obtuse, and might as reasonably be called stylospores as those of *Abrothallus.* In *Nephroma* they are narrower and oblong.

451. The genera are rare within the tropics, but *Peltidea*

occurs in the Himalayan and Abyssinian Alps. *Nephroma* is found in the north and south temperate zones, with splendid endemic species in each hemisphere. *Solorina* occurs in Europe, Abyssinia, and the Himalayas. *Erioderma*, Fée, with which unfortunately we are unacquainted, has been found only in Bourbon. We are not aware that a single species of this sub-tribe has been gathered in tropical America, but it can hardly be absent altogether. Some of the British species recur in the south temperate zone.

b. EUPARMELIACEI, *Berk.*

Apothecia at first closed; thallus horizontal.

452. In the second group, or *Parmeliacei* proper, we have the more typical species, in which the disc is at first closed and surrounded after expansion by a border arising from the thallus. The thallus is always horizontal, furnished with a hypothallus, and expands from the centre towards the circumference, or, in other words, is centrifugal. The genus *Sticta* has the habit of the *Peltigeri*, presenting highly foliaceous species, often of considerable size and of great beauty; sometimes elegantly tomentose. Indeed, amongst the horizontal Lichens, none can exceed in richness of colour, and elegance of form and outline, many of the exotic species; nor are our own deficient in beauty. *Sticta pulmonaria* is a fine species when growing in favourable positions, and spreads over a large compass, and is remarkable for its pitted frond. There is a peculiarity about the species of this genus, by which they are at once distinguishable. The under side is clothed with delicate, velvety down, amidst which are scattered round white spots, which penetrate to the medullary stratum. These have been called cyphellæ, but there is no great use in giving them a distinctive name. In some species the texture is subcartilaginous, but this is not true of all. One or two species are extremely fœtid when moist. *Sticta glomulifera* is remarkable for the Collema-like tufts, which are scattered over the upper surface. They consist of shrubby, sub-gelatinous, dark-green tufts, consisting of closely packed branched threads. The patches of this plant are sometimes three feet across. *Parmelia* contains some species which may vie with *Sticta*. *P. perforata* is

remarkable for the round holes with which the disc is perforated. *Lecanora* is distinguished principally by its crust. There are one or two genera separated from them on grounds which interest the student of this particular class of Cryptogams, rather than the general reader. *Urceolaria* deserves notice on account of its immersed, somewhat urceolate, discs, which give the species an appearance very different from that of the neighbouring *Lecanoræ.* Fries does not think them sufficiently distinct to justify their separation. *Dirina* is remarkable for the carbonaceous stratum, from which the disc springs. One or two species grow on trunks of trees in Spain and the warmer parts of Europe, or the north of Africa. *Gya-*

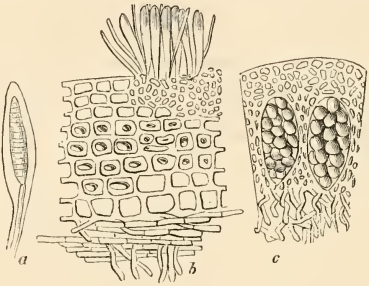

Fig. 87.

a. Ascus with young half-formed spore of *Sporopodium Leprieurii*, Mont., after Montagne.

b. Vertical section of *Coccocarpia smaragdina*, from Cuming, No. 2154, showing the sub-hymenial tissue resting on the gonidia, the cortical and medullary being altogether confluent.

c. Ditto of *Lecanora affinis.* From Erzeroum specimens communicated by Dr. Lindley.

All more or less magnified.

lecta has apparently a proper excipulum, but this is formed in reality from the thallus, though differing in substance. The disc easily falls out, and leaves the receptacle behind, which has a very peculiar aspect, and is often mistaken for a *Peziza.* *Lichen exanthematicus,* which is referred doubtfully to this genus, occurs on calcareous rocks. The apothecia are at first closed, but exposed in consequence of the dimidiate excipulum splitting in a radiating manner. The nucleus at length falls out, and leaves a little pit in the stroma. *Lecanora affinis, esculenta,* and their allies have already been spoken of on account of their curious habits, and their value as an article of food. Their gonidia deserve especial notice, because they are contained in distinct asciform cavities amongst the cortical tissue, though resting on the medullary (Fig. 87, *c*). These species vary from solid tuberiform bodies to fruticulose fascicles.

453. Tulasne has discovered spermatia in most genera, which differ considerably even in the same genus. The genera are probably all cosmopolitan, except *Dirina,* which belongs to southern Europe, the regions of the tropics, and south Africa. (We say nothing of the small and obscure genera *Gyalecta* and *Gassicurtia.*)* A considerable number of species also occur in all parts of the world. The decidedly foliaceous *Parmeliæ* abound in the cold and temperate regions of both hemispheres, but bear a much smaller ratio to the whole number of species within the tropics. Thus, to speak roughly, the foliaceous species (=*Imbricaria* and *Physcia*) are in Europe as 30 : 500, in French Guiana as 5 : 200; i.e., as 1 : 17 in one case, and as 1 : 40 in the other; so that the foliaceous *Parmeliæ* are at least twice as numerous proportionally in Europe as in tropical America. The section called *Psora* by Fries, in his Lich. Eur., is most plentiful in the temperate regions of the south. New Zealand contains, perhaps, twice as many species as we have in Britain, out of a Lichenological Flora, comprising at present about half the number of our own species, but which probably may in reality exceed it.

* By *Gassicurtia* is here meant the genus published under that name in Linnæa. The *Gassicourtia* alluded to at page 378, as having scarlet sporidia, and so spelt in Orbigny's Dictionary, is probably an anamorphosis of some Lichen, belonging to the same category as *Hypochnus.* It is now called by Fée *Cystodium,* and regarded as a Fungus, but this is evidently incorrect. The scarlet bodies are not sporidia, but granular bodies similar to those which occur in *Stegobolus,* and other genera. I can, however, only speak of them from report, as I have seen no specimen.

454. The same country, and the south temperate regions generally, are the especial seat of the remarkable genus *Sticta*. In all Europe, only about twelve Stictæ occur (several of which are almost peculiar to the western coast and Ireland, more especially to our own); whereas New Zealand and Chili each contain at least twice that number. In those parts of North America comprised in Tuckermann's enumeration (i.e., all the country north of 40°), we have only eight species, and in French Guiana only two. In other parts of tropical America, however, they are somewhat more abundant. It is remarkable that the *Lobaria* section of this genus (two species of which occur in Europe generally, and which are found also in North America, and of which the tropics have a few peculiar species) should be almost wholly absent from those regions in which the majority of the species occur. Here, however, again, we perceive how unsafe it would be to affirm its non-existence in the south temperate zone; for one species, according to Flotow, occurs at the Cape of Good Hope, and in all probability it will be found elsewhere.

c. USNEACEI, *Eschw.*

Disc open from the first; thallus mostly centripetal, vertical, or sarmentose, without any hypothallus.

455. The third sub-tribe of this large division comprises the genera allied to *Usnea*. All the species, with the exception of *Cetrariœ*, have a centripetal thallus, which is usually erect and branched, with a disc open from the earliest stage of growth. They are connected with the *Euparmeliacei* by means of *Cetrariœ*, which have very nearly the same habit. The thallus, indeed, though not absolutely erect, has an ascending direction in very young individuals, which becomes more and more vertical as it approaches maturity. Indeed, *Cetraria tristis* has only that degree of inclination which arises from its crowded mode of growth, and springs like a seaweed from a little peltate disc. *Cetraria pinastri* and *Juniperina* have the beautiful colours of a *Sticta*. *Roccella* (Fig. 18, *c*) departs from the Parmelioid type, and has the dull grey tints of *Ramalina*, assuming a fungoid or fucoid aspect. The disc, which is here open from the earliest stage of growth, is seated

on a carbonaceous stratum. The supposed species run very much into each other, and may be reduced to a very few. Their peculiar habit alone separates them evidently from *Evernia.* *Ramalina* affects occasionally the same marine habitats as *Roccella.* It is very near to *Evernia*, with some species of which it is almost confluent. The thallus is, however, more distinctly analogous to that of *Clavaria*, being always alike on all sides, without any distinct hypothallus. It is curious that while *R. polymorpha* and *scopulorum* abound in dyeing matter, *R. calicaris* is rich in gluten.

456. This sub-tribe contains three distinct types; the first distinguished by its pendulous habit; the second inflated and erect, of which *Dufourea madreporiformis* and *flammea* are well-known examples, the latter of which abounds in the guano islands, on the coast of Africa; and thirdly, the true Ramalinoid type, with which every one is familiar, from the frequency of the species on wooden structures. *Thysanothecium*, Berk. and Mont., a Swan River Lichen, is perhaps only a form of *Ramalina*, though its characters are very remarkable. The absence of fertile asci makes this the more probable. *Evernia* exhibits several types, and contains many elegant species. Thus *E. vulpina* and *flavicans* present beautiful tints, while most of the species are rather sombre. *E. jubata*, again, is remarkable for its pendulous, cylindrical branched thallus, hanging down like bunches of horse-hair from rocks and trees. *Usneæ*, finally, when well-grown, are perhaps the most beautiful of Lichens. The colours are sometimes brilliant, and the habit elegant, and, when the broad discs are amply ciliated, the appearance is very striking. The same species are widely diffused, but the colours are brighter in exotic specimens. *Usnea melaxantha* (Fig. 15, *a*), with *U. Taylori*, are splendid productions.

457. The tribe is mostly cosmopolitan, a remark which applies to species as well as genera. *Usnea*, *Cetraria*, and *Evernia*, are as genera ubiquitous, but they contain many local species. In Europe several *Cetrariæ* are almost peculiar to the Western and Mediterranean coasts. *Cetraria* diminishes greatly under the tropics. *Roccella* avoids extremes of both

hemispheres. The uses of the species have already been amply noticed. There is a trace of Lichens in Amber.

458. No vegetable productions are more liable to variation than Lichens, a circumstance which makes their study very difficult; and without a knowledge of the fruit it is almost impossible to distinguish species accurately. Not only is the crust liable to put on various forms, by the over-production of some of its constituent parts, but even where these are in a normal condition, the degree of division of its lobes, the difference of colour, the obliteration of the margin of the apothecia, the exposure of those which have a true excipulum partially covered by the crust, the greater or less crowding of the fruit, the reduction of compound forms to simple, and many other circumstances, induce variations which can only be appreciated by the practised student. The tropical *Verrucariæ*, for instance, assume forms so different, that without a comparison of the fruit it is almost impossible to come to any correct judgment, and in these the Lichenoid character is sometimes completely obliterated by the non-development or evanescence of the crust.

459. A general hypertrophy of the crust is also a source of much embarrassment. A very peculiar form of *Parmelia saxatilis* was lately figured by myself in the Gardeners' Chronicle, 1856, each plant lying free upon the ground and forming a dense round ball consisting of narrow lobes, in which their peculiar sculpture was almost obliterated. There is also some reason to believe that other free Lichens, as *Lecanora affinis* and *esculenta*, may be due to a similar hypertrophy; but this at present is mere conjecture. Many other forms are assumed by the crusts of Lichens; the granulated arising from the development of chlorophyl, bursting through the cortical stratum, or from the external cells of that stratum itself, the squamulose from an analogous hypertrophy, the soredioid from the protrusion of groups of gonidia, which, when excessive, gives rise to such productions as *Variolaria;* the proliferous, which is an exaggeration of the squamulose; the isidioid, in which the thallus is broken up into short erect cylindrical projections. These must all be kept in view by

the student who wishes to attain correct views as to species; and at the same time he must be equally on his guard against changes in the fruit which might easily deceive. The different varieties, for instance, of *Leptogium bullatum* present apothecia both with and entirely destitute of a margin. The structure of the thallus* itself requires more extensive comparative study than it has received at present, especially as regards the mode of production of gonidia. On all these points the introductory remarks of Fries in his Lichenographia Europæa, should be thoroughly examined, though implicit faith must not be reposed in every view put forth in that work regarding species.

460. No plants are more easily collected and preserved than Lichens, with the exception of the rock species, of which it is not always easy to secure good specimens. Capt. Carmichael used to gum a piece of paper to specimens which he wished to detach from the surface of rocks which it was impossible to break, and then shave them off with a knife, leaving them attached to the paper; the specimen was then glued down, and the upper paper removed by damping. Such a plan could only be followed where a person has a tolerably permanent residence, and the specimens are liable to injury from being impregnated with the gum. When once dried, Lichens are less subject to injury from insects than most other plants; but I have known them completely decomposed when in a constantly damp atmosphere.

461. It is a convenient thing to have sections of cellular

* If the structure of the thallus were more completely ascertained, there would be less difficulty in deciding upon the true nature of *Coccocarpia*. In *C. incisa* and *smaragdina*, I find scarcely anything which can be called medullary tissue, at least agreeing with that in other Lichens. The gonidia, moreover, are the endochromes of cells lying between the hypothallus and cortical stratum, and not distinct free cells. In the latter, as represented in the Flora of New Zealand, I find gonidia underlying the tissue which supports the hymenium. The thallus is, in fact, so different from that of other Lichens, that at present I am constrained to consider it as part of the same organism with the apothecia. I have represented the structure as I find it in the latter species, at Fig. 87, *b*.

Cryptogams preserved in fluid ready for use; and many Algæ suffer so much from drying, that fresh specimens preserved in fluid are in many cases almost indispensable. Many media have been proposed, as solutions of creasote, glycerine, and other matters secured from evaporation by a quickly drying cement, and one which will not penetrate the cell in which the specimen is contained. The method adopted by Mr. Thwaites, and described in the Annals of Nat. Hist., vol. xv., p. 104, was not perfect in this respect, though I have a large number of specimens prepared by him, which have stood the test of some years. Whatever the fluid may be which is preferred, a cell must be prepared with a mixture of gold size and japan-black, rubbed down with lamp-black and litharge, lamp-black, or marine glue, in the centre of an oblong slip of glass, taking care that it is perfectly dry before it is used. This is then filled with the preserving fluid, and the specimen nicely placed in it, perfectly free from air bubbles. A piece of microscopic glass is then placed over the cells, and the edges cemented securely with the same mixture. The preparation of good specimens is a work of much nicety, and can only be carried on successfully by those who are prepared to meet difficulties from their own resources. A full account of the necessary manipulation will be found in Queckett's Practical Treatise on the Microscope, to which, for want of room, I must refer for further information. Such methods, it may be observed, are equally available for many objects belonging to vascular Cryptogams. See also Ann. of Nat. Hist., vol. xxi., p. 351.

CLASS II.—ACROGENS. *Lindley.*

ACROGENÆ, *Brongn.*—ACROBRYA, *Mohl., Endl.*—PSEUDOCOTYLEDONEÆ, *Ag.*—HETERONEMEÆ, DIPLOGENEA, CRYPTANDRA, *Fr.**

MOSTLY herbaceous, provided with distinct often stomatiferous appendages, and frequently containing vascular as well as cellular tissue. Spores producing a prothallus or developed at once into a perfect plant. Spermatozoids spiral. The characters may be given in terms of the distinctive names as follows:

1. *Vascularia, Heteronemeæ, Diplogeneæ.*
2. *Acrogenæ, Acrobrya.*
3. *Pseudocotyledoneæ, Cryptandra.*

462. The second great class into which Cryptogams are divided, with the exception of *Characeæ* and a few obscure *Hepaticæ,* is at once distinguished by the presence of foliaceous appendages bearing some resemblance to those of Phænogams. In many instances stomates are present, and the functions are, to a greater or less extent, the same. The stem itself in many cases has distinct vascular tissue. Even in those plants, as *Jungermanniæ,* where vascular tissue is very rare, we have distinct unrollable spiral vessels in the elaters. In mosses again, which have no elaters, genera exist, as *Sphagnum,* in which the leaf-cells contain a well-developed spiral. Such tissue is often scalariform; but in *Isoetes* and *Equisetum* it is distinctly annular, with transitions to short spirals; while in *Selaginella*

* With the exception of the names used by Fries and Brongniart, the above terms are not absolute equivalents of Acrogens, as understood in the present volume, *Characeæ* being, for the most part, classed with Thallogens.

and *Lycopodium*, there is a transition from short spiral and reticulated cells to elongated cells, which may be called spiral vessels. Perforated cell-walls are found in a few mosses, and in the stem of *Sphagnum* tissue occurs just like the so-called glandular tissue of Conifers.*

463. The most important distinctive character of Acrogens, however, is the complete differentiation of the sexual apparatus, attended by or resulting in peculiarities which separate these plants from all others. If impregnation take place in Thallogens, it is by the contact of the spermatozoa or spermatia with the spore or sporidium. At least, such is the case in those Algæ where the process (p. 89) has been verified.† And in those few Fungi (p. 10) where there is an analogue of a prothallus, the prothallus has the character of a spore, whether that or the spore of the second order be the body which receives impregnation. In Acrogens, at least those in which spores are produced, impregnation does not take place in the spore itself, but in a distinct organ produced upon the frond or other body to which the germination of the spore gives origin. In *Characeæ* alone, which approximate Algæ, there are spores properly so called; at least, if the nucule be considered as containing a single solitary spore, but it is not certain whether this is the result or the subject of impregnation.

464. So much has been said of the habits of Cryptogams in general, and of the relations of the higher forms to Phænogams, that it is unnecessary to extend the general remarks, particular information being reserved for each distinct head. It need only be added, that, though the traces of Thallogens in geological strata are for the most part obscure and uncertain, we have abundant and undoubted remains of Acrogens, which prove that they performed an important part in the economy of the world before the introduction of man.

465. I have already, at page 45, given a general notion of the mode of fructification which exists in the higher Cryptogams. It may be well, however, to restate the matter in a

* See Hofmeister, Verg. Untersuch., tab. 13, fig. 8, 8 *b*.

† Pringsheim's latest views will be given at the end of this volume.

few words. The spores of all germinate or undergo a process of cell-formation, homologous with germination, though no threads or external organs are protruded. In the one case, after a time, plants are formed upon the germinating threads, which are, in fact, of the same nature as a mycelium, or the plant is formed without any distinct mycelioid condition; in the other case, a body is generated of various forms, called a prothallus, which answers the same purpose as the perfect plant in the former, so that the prothallus in the one case is homologous with the plant in the other. In both alike, urn-shaped cavities called Archegonia appear, from a privileged cell of which, after impregnation, a sporangium is formed in the one case, and in the other a plant capable of producing sporangia. Perennial *Musci* and *Hepaticæ* so far agree with Phænogams, that there is a fresh crop of fruit each year; but then the result of impregnation is not a seed, but an organ, which produces the reproductive bodies or spores, much after the fashion in which pollen grains are generated. Ferns and Clubmosses, though living to a hundred years, and producing a crop of spores each year, are impregnated but once, and that before the plant has assumed its true habit. The result of impregnation in these is something more or less resembling the embryo of a Phænogam, and, like that, produces by progressive development a perfect plant.*

466. As regards classification, we have three distinct groups into which Acrogens are divisible: 1, Those in which the single spore is, in all probability, immediately impregnated, and in which there is no prothallus, as *Characeæ;* 2, Those in which the whole plant, whether annual or biennial, is the immediate parent of the fruit, the result of impregnation being the production of fruit from an embryonic cell, as in *Musci* and *Hepaticæ;* and 3, Those in which the result of impregnation is a new plant, whether annual or perennial, producing one or more successive crops of fruit, as *Filices.*

* Illustrative figures will be given under the respective orders, which may be consulted in explanation of the terms here used.

ACROGENS.	CHARACEALES.	Spores or nucules solitary.		*Characeæ.*
	MUSCALES.	Spores numerous, giving rise to a plant which produces one or more successive sets of fructifying archegonia.	*Hepaticæ.* Peristome, 0.	*Ricciaceæ.* — Sporangia valveless without elaters.
				Marchantiaceæ. — Sporangia dependent, valvate or bursting irregularly. Spores mixed with elaters.
				Jungermanniaceæ. — Sporangia erect, valvate. Spores mixed with elaters.
			Peristome mostly present.	*Musci.*—Sporangia valveless, operculate, without elaters.
	FILICALES.	Spores numerous, producing a prothallus which bears a single set of archegonia, which yield fructifying plants.		*Filices.*—Sporangia annulate, or rarely exannulate and closely crowded
				Ophioglossaceæ.— Sporangia exannulate, bivalvate.
				Equisetaceæ. — Sporangia dependent, unilocular, bursting laterally.
				Marsileaceæ.— Sporangia multilocular.
				Lycopodiaceæ.—Sporangia axillary, unilocular.

467. As in former instances, and indeed in every artificial arrangement, there are exceptions to these characters. In *Cyathodium* there is something like the peristome of mosses; in some *Jungermanniæ*, the rupture is irregular; in *Andræa*, which appears to me a moss, the fissure is valvate, with the tips cohering as in *Jungermanniæ;* in several mosses there is no peristome, and in some the lid does not separate; and in *Danæa* and its allies there is no ring. In all these cases, however, the affinities are so clear, that the student will experience little difficulty when the exceptional cases are once pointed out.

468. *Characeæ* are analogous to *Confervæ*, *Hepaticæ* to Lichens, while some *Marsileaceæ* have almost the foliage of Phænogams. There is, however, no more connection between the two former groups and their analogous Thallogens, than there is between the latter and Phænogams. Thallogens and Acrogens belong to two definite divisions, as acutely separated from each other as Phænogams are from Cryptogams. There is not, as far as I am aware, a single real link like that between Algæ and the animal kingdom. Their affinities are far too strongly stated in Dr. Lindley's Vegetable Kingdom, p. 52. *Riccia* has no relation that I can see to Lichens. The other instances mentioned of the relation of Clubmosses to Conifers, Ferns to Yews, and Mosses to *Dacrydium*, are all mere cases of analogy.

ALLIANCE III.

Characeales, *Berk.*

Acrogens consisting of confervoid articulated threads, simple as in *Cladophora*, or compound as in *Polysiphonia*. Fruit monœcious or diœcious. Female: spores coated with spirally arranged cells, at once reproducing the plant. Male: brick-red globules, consisting of eight spherically triangular divisions, from the centre of each of which a centripetal column springs perpendicularly, bearing towards the apex articulated threads, the articulations of which produce a spiral spermatozoid.

CHARACEÆ, *Rich.*, *Brongn.* CHAREÆ, *Kütz.*

469. This is a small order consisting of but three genera. All the species are aquatic, and unable to endure much exposure to the atmosphere. They are more or less diffused over the whole world, being as abundant in some parts of the southern hemisphere as in the northern.* The nucules of *Characeæ* occur in the lower fresh-water formation, and in succeeding strata, and are known under the name of *Gyrogonites.* They have attracted more attention than such obscure plants might otherwise have done, from the curious structure of their antheridia, and the clearness with which the circulation is seen, in one at least of the genera, under the microscope.

470. *Nitella* differs from *Chara*, in having very nearly the structure of a *Cladophora*, consisting, that is, of threads formed of joints, placed end to end, and more or less branched. These distinctions are not, however, absolute. *Charopsis*, Ruprecht, contains those uncoated monœcious species in which the antheridium takes the place of one of the bractes, and the nucule is seated directly above it; in other words, the nucule is axillary. In *Lychnothamnus*, Ruprecht, the species are also monœcious, and the antheridium is placed by the side of the nucule. *Charopsis*, Kütz., includes both genera. In *Characeæ*, however, all the divisions are more or less perfectly disposed in whorls. There is a creeping root which sometimes produces nodular reproductive bodies, rich in starch grains; and besides these amorphous masses, stellate bodies occur in *Chara stelligera*,† which arise from a modification of the nodes, composed of cells filled with starch grains.

* See Braun in Hook. Journ. 1849, p. 193. One species only is noticed in the Flora of New Zealand, but several others occurred, which could not be described in consequence of defective materials. The Australian species are mostly *Nitellæ*.

† Montagne, Ann. d. Sc. Nat., sér. 3, vol. xviii., p. 65.

These bodies are reproductive, and replace the nucules, which do not appear to be formed when these are produced, for they are not to be found in every specimen. The antheridia are globular bodies of a deep brick red, the walls of which are divided by three great circles, two of which are vertical, and the third equatorial, into eight equilateral spherical triangles. Each of these consists of a circle of radiating cells meeting in the centre, from whence a perpendicular column penetrates into the centre of the globule,* where they meet a ninth proceeding from the base. At the point of juncture, numerous confervoid threads are given off, each cell of which produces a spiral spermatozoid, with two flagelliform appendages, resembling those of *Hepaticæ* and *Musci*. I have explained the morphosis many years since, in English Botany, under *C. Hedwigii*, as a fascicle of branchlets given off from the tip of

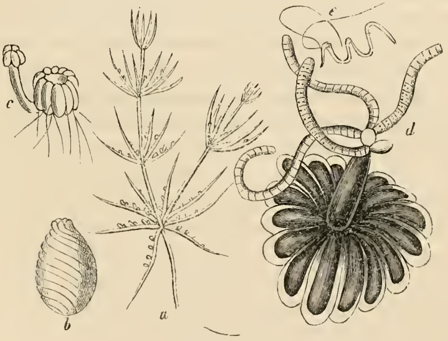

Fig. 88.

a. *Chara Hedwigii*, nat. size. From specimen gathered at Sandwich.
b. Nucule of ditto, magnified.
c. Bulbs of *Chara stelligera*, after Montagne.
d. One of the eight divisions of the antheridia of *C. fragilis*, with its column, and the threads which produce the spermatozoids.
e. Spermatozoid, after Thuret.

* Thuret, in Ann. d. Sc. Nat., sér. 3, vol. xvi., tab. 9.

the axis, radiating in eight different directions, and each producing a whorl of branchlets, so as together to form a sphere. I have seen no better or more probable explanation. Walroth's observation that he has seen the globules germinate, has never been confirmed.

471. The nucules or spores consist of a central sac filled with starch cells, coated with five cells, wound spirally round it, the tips of which are free. The nucules germinate by the formation of a cell at the tip of the central sac, which is soon developed downwards into rootlets, and upwards into a stem, so that the germination looks extremely like that of a monocotyledon. There is in an early stage of growth, a canal leading down to the central cell, which forms a passage for the spermatozoids. Their entrance has, however, as I believe, not at present been observed.

472. One of the most remarkable phenomena about *Characeæ* is the circulation, which was first discovered by Corti, and respecting which many treatises have appeared. In *Chara*, where the axillary cells are coated with an external layer in the walls of which are deposited multitudes of rhomboidal crystals of carbonate of lime, it is not easy to observe the phenomenon. Recourse should, therefore, be had to some species of *Nitella* in which it may be observed distinctly with any tolerable microscope. The chlorophyl grains in each articulation are disposed in two bands in a spiral direction, so as to leave a colourless quiescent space. The central fluid is inactive, but between this and the stratum of chlorophyl a circulation of the protoplasmic mass takes place from below, upwards, till it reaches the top of the cell, when it turns downward, ascending again when it gets to the base; and so moving so long as the vital powers are active, like an endless band in a piece of machinery. If a ligature * is tied round the cell, the place of the ligature comports itself exactly like an ordinary node, the downward circulation of the upper half, and the upward of the lower half being diverted at that point.

* See Dutrochet, in Ann. d. Sc. Nat., sér. 2, vol. 9, tab. 2. See also Donné's Memoir, l. c. vol 10, 346, with Dutrochet and Brongniart's report.

Agents destructive to life, if sufficiently energetic, arrest the circulation ; if not powerful enough to destroy it altogether, they merely arrest it for a time till the equilibrium is restored. This motion is accelerated by heat within certain limits, and beyond these it is gradually diminished; it is again accelerated, and at 113°, Fahr., it ceases altogether. Electricity, in a similar manner, produces temporary arrests of motion, but it does not seem to cause acceleration. Brongniart and Dutrochet saw similar effects produced by pressure. Dutrochet afterwards placed a *Chara* under the influence of a powerful electro-magnet. It had, however, no effect on it whatever. Neither magnetism nor electricity, then, are the causes of the motion. The first has no influence on the motion, the other acts merely as any other exciting cause, and the vital action must be considered as something *sui generis.** Various bodies have been observed by Goeppert, Cohn, and Carter, in the circulating mass, whose nature is not perfectly ascertained. All are probably not of the same nature. Some are apparently gonidia, and others infusoria. Some of these bodies, according to the former authors, are densely clothed with vibrating cilia, and something of the same kind appears to have been observed by Carter. For particulars I must refer to the papers quoted below.†

473. Many of the species emit an intolerable smell of sulphuretted hydrogen, which is supposed to cause fevers in some districts, as in the Pontine marshes. I have, however, known a whole district pervaded by this smell, for many days together in very hot weather, without producing the slightest bad effects. It has been suggested that they may be useful as manure, from their containing carbonate and phosphate of lime.

474. *Characeæ*, like other Cryptogams, are subject to great variations, which make the species difficult of determination. Not only does the size, the degree of ramification, the produc-

* See Comptes Rendus, Ap. 15, 1846, and Ann. of Nat. Hist., vol. 17, p. 451.

† Bot. Zeit. 1849, p. 665, &c.; Ann. of Nat. Hist., n. s., vol. 17, p. 101.

tion of superficial bristles, and of descending threads like those of some *Callithamnia* (Fig. 26), vary, but the deposit of mineral matter in the cuticle, the coating of the axis, the form and size of the nucules, are almost equally uncertain. The geographical limits of individual species are, therefore, frequently doubtful, and will probably remain so till the effect of climate and the chemical constitution of the water are known. Though salt is injurious to most of the species, a few can bear brackish water without injury.

ALLIANCE IV.

Muscales, *Lindl.**

Cellulares Foliaceæ, *D. C.*—Heteronemeæ, *Bartl.*—Muscoideæ, *Lindl.*—Anophyta, *Endl.*—Muscosæ, *Perleb.*

Spores numerous (never at least solitary), produced within variously formed capsulæform organs, giving rise after germination to an annual or perennial frond, or foliiferous plant; Archegonia springing from the perfect plant, and producing after impregnation sporiferous fruit, which is either sunk in the frond, or superficial, with or without external envelopes in addition to the calyptra or persistent Archegonium.

475. Different as the horizontal Licheniform frond of many *Hepaticæ* is from the erect foliiferous mosses, a minute inspection of characters at once shows their intimate relation, and a distinct connecting link presents itself in the genus *Andræa*, which, though essentially a moss, has something of the outward habit and peculiar dehiscence of *Jungermanniæ*. All agree in producing from the germinating spores without any intermediate prothallus, though there is something occasionally

* Dr. Lindley includes *Equiseta* amongst Muscales. In other respects his division is the same as mine.

after the fashion of a mycelium, a perfect plant, which if annual produces a single set of antheridia and archegonia (Fig 89, *c*, *d*, *e*, &c.), or if of longer than annual duration a new set for every year, except in those cases where the plant does not arrive at maturity in the first season. There is, indeed, considerable diversity in the fruit thus produced, which may consist of a simple sac, as in *Riccia*, immersed in the

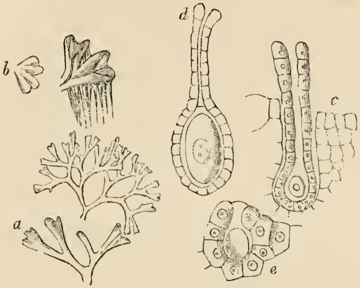

Fig. 89.

a. Riccia Fluitans. nat. size, and slightly magnified.

b. Riccia natans, nat. size. Both received from Mr. E. Skepper. One specimen has lost all its fringe.

c. Archegonium of *Riccia glauca* in an early stage of growth, vertical section.

d. Ditto with embryonic cell just ready for impregnation.

e. Vertical section of very young antheridium. These three figures are borrowed from Hofmeister.*

substance of the frond, of a similar sac, raised above the surface upon a peduncle, and covered with one or more envelopes, as in *Jungermanniæ;* these sacs again may be collected into groups, and disposed symmetrically on distinct pedunculate organs, as in *Marchantiæ*, or the organ which contains the spores may be still more complicated, bursting by a horizontal fissure and

* Vergleichende Untersuchungen der Keimung, Entfaltung und Fruchtbildung höherer Cryptogamen. W. Hofmeister, Leipz., 1851. Consult also Unger in Linn., v. 13, p. 1, on the development of *Riccia glauca.*

furnished at the mouth with delicate processes, which close the orifice, or leave it open for the escape of the spores, according to the hygrometric condition of the air, as in mosses. In some cases the spores are unattended by any threads; in others there are numerous threads attached to the walls, whose cavity is traversed by one or more spirals, performing, in fact, the same function as the teeth round the orifice of the moss capsule. Whatever questions may have been raised formerly as to their sexuality, there is no doubt about the question now. Hofmeister has in every group, following the steps of Unger, Mohl, and others, traced out the formation both of the antheridia and archegonia, and has shown in most cases, that in the former spermatozoids are generated ; while Thuret and others have taught that these bodies combine the characters of those of Algæ, with a closer approximation to the true spermatozoa of animals.

476. Besides the essential fruit, many species are propagated largely by gems produced at different parts of the plants. These are sometimes seated on distinct pedunculate processes, sometimes at the tips of the leaves, sometimes at the base of cup-shaped or lunulate receptacles, like the sporangia in the cup of a *Nidularia*. They appear first as single cells projecting from the surface, and then by cell-division are transformed into bodies of various forms and thickness, which are at length detached, and propagate the plant like the bulbiform buds of *Dentaria*, *Lilium*, &c.

HEPATICÆ, *L.*

Fertile sacs opening regularly or irregularly, without any definite lid ; borders of the fissure naked, not provided with any series of teeth (peristome) single or double.

477. This group comprises three very distinct natural orders, *Ricciaceæ*, *Marchantiaceæ*, and *Jungermanniaceæ*, whose characters will be described under the respective heads. The species are known in England under the name of Liverworts, though they are confounded more or less in popular phraseology with the Peltigerous Lichens. Where the frond is not Licheniform, the leaflets have seldom the more or less ovate form of those in mosses, but often assume strange outlines,

attended by curious appendages and stipules, while the colour far more frequently assumes a purple hue, which is, however, not confined to the foliiferous species. There is a peculiar aspect about them by which they are known at once, except in a very few cases, and the slightest experience is sufficient even in these to prevent much hesitation.

I. RICCIACEÆ, *Endl.*, *Lindl.*

RICCIEI, *Nees ab Esenb.*,* *Bischoff*, *Lindenb.*, &c.

Sporangia valveless, sunk in the substance of the frond, or raised above its surface; surrounded by or adnate with the calyptra, with or without additional envelopes, ultimately bursting irregularly, and producing numerous spores without elaters.

478. The characters of this group are many of them negative, but the valveless sporangia, whether raised above the surface or buried beneath it, taken in conjunction with the constant absence of elaters, will always sufficiently indicate its members. The simplest species belong to the genus *Riccia* (Fig. 89, *a*, *b*), which exhibit a horizontal, more or less dichotomous, lichenoid frond, which often appears like some *Endocarpon* or barren *Jungermannia*. The fruit, which consists of a spherical sac filled with spores, is sunk into the substance of the frond, in consequence of which the resemblance to an *Endocarpon* is still stronger. But the mode of origination of the spores is totally different: in *Riccia* they arise from the repeated division of mother cells, exactly after the fashion of pollen grains, whereas in *Endocarpon* the sporidia are generated without cell-division from the protoplasm of the asc (Fig. 82, *c*). There is, therefore, no affinity whatever, though the external resemblance is so strong. They differ, moreover, materially, in having a distinct axis of growth, which exists in no foliaceous Lichen, and in the presence of air passages beneath the porous outer surface in some species, as in

* In all that relates to Hepaticæ, I have to acknowledge my obligations to the Synopsis Hepaticarum of Gottsche, Lindenberg, and Nees von Esenbeck.

Oxymitra pyramidata and *Corsinia Marchantioides.* In some species of *Riccia** there are many air passages between the cells, besides the large cavities in which the archegonia are produced. The species are either terrestrial, epiphytous, or aquatic; and the same species may assume each of these habitats, with slight alterations in consequence of the change. The under surface is often beset to a greater or less extent with thin scales, which are especially remarkable in *Riccia natans* (Fig. 89, *b*).† In some species the margin is ciliated. The species have a wide extent, but are more numerous in Europe than elsewhere, especially towards the south. *Riccia cochleata* of the Antarctic Flora is a doubtful species. Unfortunately it was not found with fruit, and therefore its true affinities are obscure. It approaches by its lobed margin to *Jungermanniæ.* Three species occur in New Zealand, and several at the Swan River. *Oxymitra* differs from *Riccia,* in the more prominent fruit, and in having a proper involucre, though it has no common involucre, while *Corsinia* has the habit of *Marchantia* and superficial fruit, with a common paleaceous di- or pluri-phyllous envelope. Both these genera belong eminently to the south of Europe, extending in the second instance as far as the Canaries. There is, however, in Sir W. J. Hooker's Herbarium, a species marked *Riccia paradoxa* (Fig. 91, *a*), gathered in Brazil by Gardner.‡ Each sessile globose sporangium has a di-triphyllous involucre, consisting of broadly ovate leaflets clasping the fruit, without any foliaceous scales or divisions. This should certainly form a distinct genus; for it is not, as was supposed, concocted from a *Riccia* and a *Corsinia.* The involucre is not general, but partial and of a different order, therefore, from that of *Corsinia.*

* See Unger in Linn., vol. 13, tab. 1. These air passages do not, however, exist in every species.

† The scales in *Riccia natans* are a most beautiful microscopical object when treated with different chemical tests, from their transparency and variety of colouring.

‡ See Hook. Lond. Journ., vol. 3, p. 166. As it is quite clear that it is no *Riccia* or *Corsinia,* and is more nearly allied to *Sphærocarpus* than to either, I beg leave to propose for it, as a generic name, *Cronisia.*

C. Marchantioides occurs also at Buenos Ayres and the Swan River. *Sphærocarpus* (Fig. 90, *a*, *b*, *c*) has superficial fruit with a sessile or pedicellate proper involucre. The species occur in temperate parts of either hemisphere. The most curious genus of all is *Riella* (Fig. 90, *d* to *g*, formerly *Duriæa*,*

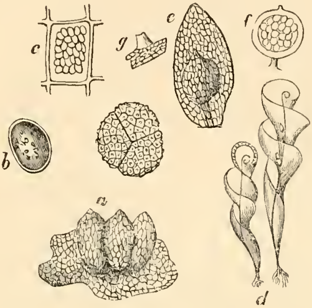

Fig. 90.

a. *Sphærocarpus terrestris*, slightly magnified. From a Lyons specimen given me by Dr. Montagne.

b. A young mother-spore before division, together with an old triple spore, with its areolate verrucose surface. From Moug. and Nest., No. 1045.

c. One of the cells of the wall of the sporangium filled with starch grains.

d. *Riella helicophylla*, male and female, nat. size From specimens given me by Durieu de Maisonneuve.

e. Perianth and inclosed sporangium.

f. Sporangium.

g. Orifice of sporangium.

which differs from the rest in its erect habit. The stems are branchless and have a distinct wing or leaflet, forming a continuous spiral round the stem, much after the fashion of the stomach of a shark. In the male plant the edge of the frond bears the antheridia; in the female the fruit springs from the

* Montagne, in Ann. d. Sc. Nat., sér 3, vol. 18, p. 11.

stem. It has a sessile proper involucre. The spores, according to Montagne, are solitary, and strongly echinulate. They are not mature in my specimens, and in this condition are perfectly smooth. In *Sphærocarpus*, *Riccia*, and many other Acrogens, on the contrary, four spores are formed from the contents of one mother cell. They present, therefore, as the division is not equatorial, three plane and one convex surface. One species occurs in Algiers, the other in Sardinia. *Riella*, like *Subularia*, bears fruit under water; but in the aquatic *Ricciæ* fruit is rare, except where the fronds are stranded on the bank. I am not aware that any of the species can rank as more than mere botanical curiosities.

479. These plants are subject to considerable variation both in the breadth and division of the fronds, and the degree of projection of the sporangia. The scales also, with which many are clothed, are by no means constant in size and form, or even in number; though, perhaps, in species of which they are characteristic, they never fail entirely, except from accident, as I have seen to be the case in *Riccia natans*.

II. Marchantiaceæ, *Cord.*

Marchantieæ, *Nees ab. Esenb.* Cephalothecæ, Cephalothecia, *Dumort.*

Sporangia valvate or bursting irregularly, for the most part disposed symmetrically on the under side of pedunculate rotate receptacles, mostly arising from the transformed margin of the frond; rarely solitary and sessile: peduncle often sheathed or involucrate. Spores mixed with elaters. Antheridia contained in proper sessile or pedunculate, peltate or discoid receptacles. Cuticle areolate, porous.

480. The distinctive character by which these *Hepaticæ* are known from *Ricciaceæ*, consists in the elaters with which the spores are mixed. These are no less conspicuous in *Jungermanniæ*, but the sporangia are always solitary in that order, though they are evidently connected with *Marchantiaceæ*, by means of *Lunularia* (Fig. 93, *d*). Mr. Henfrey has very care-

fully observed the morphosis of the elaters.* The sporangia are at first filled with a mass of oblong cells, some of which are broader than the others. The protoplasm of the broader contracts into a number of separate masses. These occasionally are divided again longitudinally, so as to form a double row, and in either case each becomes a mother cell. The narrower, on the contrary, produce the elaters (Fig. 91, *b*).

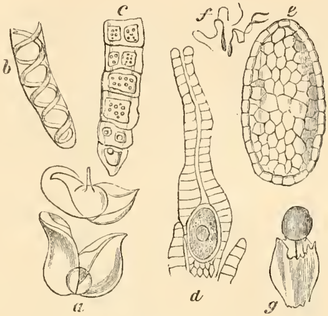

Fig. 91.

a. Fruit of *Cronisia paradoxa*. From a sketch in the Hookerian Herbarium.

b. End of elater of *Marchantia polymorpha*.

c. One of the broad cells with the endochrome breaking up into mother cells, after Henfrey.

d. Section of *Archegonium* of ditto, with embryo cell, and the proper involucre at the base, after Hofmeister. This, *in situ*, is dependent.

e. Antheridium of *Targionia*, after Thuret.

f. Spermatozoids of the same.

g. Sporangium of *M. polymorpha*, and proper envelope.† (See Fig. 92, *d*.)

All more or less magnified.

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* Linn. Trans., vol. xxi., p. 103.

† This is said to be formed from the pistillidium, by Henfrey, l. c. The pistillidium or archegonium, however, is adherent to the base of the peduncle when the sporangium is protruded.

The protoplasm first generates a number of starch granules, and after a time these are absorbed, and a double spiral, consisting, however, of a single thread, is formed on the walls. Mr. Henfrey compares this very correctly to a piece of string doubled and then twisted.* This is not, however, the only part of *Marchantia* in which spirals are developed in the cells; for in the walls of the sporangia, the cells are partly annular and partly distinctly spiral.

481. Thuret has illustrated the spermatozoids of *Marchantia*, *Fegatella*, and *Targionia*, in his memoir on the fecundation of Algæ so often quoted. They resemble those of *Chara*, but in an early stage have fewer volutions in the spiral, which at a later period is almost completely expanded (Fig. 91, *f*). *Marchantiaceæ* are divided into three distinct groups, according to the character of the fructification.

MARCHANTIACEÆ.	*Targionieæ.* — Sporangium solitary, sessile.
	Jecorariæ.—Sporangia on a common pedunculate receptacle.
	Lunularieæ.—Sporangia on a common peduncle.

1. Targionieæ, *Nees.*

Targioniaceæ, *Endl.*

Frond horizontal, foliaceous. Fruit terminal, inferior, sessile, with a bivalved single fruited involucre. Sporangia nearly sessile, bursting irregularly or with six teeth.

482. This tribe consists of two genera, one of which is distributed over almost the whole world, extending as far south as New Zealand and the Swan River; the other, as far as at present known, is confined to Cuba. *Targionia* grows on sunny banks, and in some countries, as in Portugal, is almost always accompanied by *Lunularia*, though they have no intimate relation to each other, except as far as both belong to

* Compare also Henfrey's remarks on the structure of the elaters of *Trichia*, in Linn. Tr., vol. xxi., p. 221.

Hepaticæ. *Targionia* has a Lichenoid frond slightly forked, with a central midrib, porous above, and clothed below with scales and rootlets, and often exhibiting a dark purple tint. The sporangium is clothed by the remains of the archegonium, without any proper involucre. The general involucre is bivalvate. More than one archegonium is contained within the sac at first, but of these one only is impregnated, or at least one only comes to perfection; the male fruit is in scaly buds, which proceed from the lower side of the midrib, with an exposed disc, in which the antheridia are deeply immersed.* Sometimes the plant is diœcious, sometimes monœcious. The spermatozoids are at first spiral, and then expanded with two flagelliform delicate appendages (Fig. 91, *f*). The other genus, *Cyathodium*, has also a bilabiate involucre, containing a single sporangium, which splits above into, generally, six teeth, coloured above. The upper portion of these teeth is formed by the junction of many tubes of unequal length, transversely striated with semicircular fibres. It has, in fact, a sort of peristome, but one, perhaps, only analogous with that of mosses. It does not appear, at least from the description, what precise relation it bears to the archegonium. The only species occurs in subterraneous caverns, and in fissures of rocks, which are never penetrated by the light.† *Targionia* varies in the width and thickness of the frond, its form, and in the comparative number of the pores.

2. Jecorariæ, *Nees.*

Fruit produced on the under side of a pedunculate receptacle, arising mostly from a transformation of the margin of the leaf. Peduncle often sheathed or involucrate. Archegonia always dependent.

483. This tribe is placed here partly on account of its immediate connection with *Targionia*, and partly because of the intimate relation of *Lunularia* (Fig. 93, *d*) to *Jungermanniæ*. *Jecorariæ* are especially remarkable for the peltate peduncu-

* Mont., Ann. d. Sc. Nat., sér. 2, vol ix., tab. 3.

† Mont., Cuba, p. 191.

late receptacles, to the under side of which the sporangia are attached, accompanied by various involucres. They occur in all parts of the world, but, perhaps, are more numerous in warmer climates. The species, moreover, have a wide geographical range. *Marchantia polymorpha*, for instance, occurs in all temperate climates, and appears in Java and Abyssinia. Its power of enduring heat, provided there be plenty of moisture, is shown by its flourishing as it does in hothouses. Every genus occurs in Europe, with the exception of the doubtful *Rhacotheca*, which at present has been found only in the Azores. The species appear to be of little use. Medicinal properties are attributed to some, and the different species are popular remedies in England for jaundice, consumption, and other maladies; but their virtues are, in all probability, quite imaginary; and within my own experience *Marchantiæ* are vulgarly confounded with *Peltigeræ*.

484. The genera are distinguished by the manner or extent to which the receptacle is lobed, by the greater or less crowding of the sporangia, by the nature of the involucre, and, above all, by the way in which the sporangium bursts. In *Fegatella* the receptacle is reduced to the thickened apex of the peduncle; in some cases, as in *Duvalia*, it is quite entire; in *Marchantia* (Fig. 91, *a*) it bursts by means of short teeth; in *Preissia*, by several deep laciniæ; in *Sauteria* and *Dumortieria* (Fig. 92, *a*), it is semivalvate; in *Fegatella*, the teeth are revolute; in *Reboulia* the sporangium is irregularly torn or sub-operculate; in *Grimaldia* it is horizontally divided in the centre (circumscissum); in *Duvalia* and *Fimbriaria*, above the centre, so as to form a sort of operculum; in *Rhacotheca*, the mode of rupture is variable, being semivalvate or horizontal.

485. The archegonium or calyptra does not always embrace the sporangium closely, as in *Riccia*, but looks like a proper involucre. The proper involucre or perianth is sometimes reguarly fissured, as in *Fimbriaria* (Fig. 92, *b*), for the escape of the spores. The peduncle of the female fruit, it should be observed, is not similar all round. One side is generally strongly grooved, while the other is round. It has, in fact, an

upper and under side, as if it were a prolongation of the frond.

486. The male fruit is borne on distinct pedunculate or sessile processes, often resembling more or less the female receptacles. The antheridia are immersed in their substance exactly as the

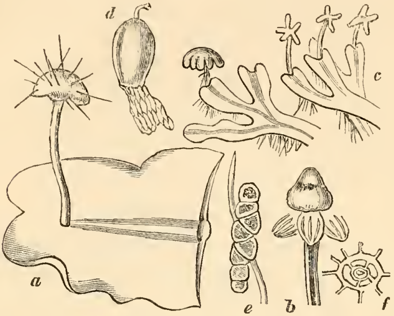

Fig. 92.

a. Dumortieria trichocephala. From a sketch in the Hookerian Herb.

b. Receptacle with the fissured perianth of *Fimbriaria fragrans.* From Hook. Herb. Slightly magnified.

c. Marchantia chenopoda, from St. Vincent's. From Hook. Herb.

d. Marchantia polymorpha. Young sporangium still involved in the archegonium, with part of the proper involucre, or perianth reflected at the base. Slightly magnified.

e. Mother cells, and young elater from the same. More highly magnified.

f. Stomate.

perithecia are in *Poronia punctata,* a Fungus which is common on the dung of animals in most parts of the world, in one or other of its forms. The spermatozoids resemble those of *Targionia* (Fig. 91, *f*). The cuticle of the frond is areolate and porous. The pores, however, are not precisely homologous with the stomates of Phænogams, though their functions are the same. There is a distinct midrib, from the under side of which rootlets are given off, which perforate the scales with which it, as well as the rest of the surface, is often clothed, exactly as the scales of bulbs, or the bases of the leaves, are perforated by the adventitious roots in many monocotyledons. The species vary in the breadth and thickness of the fronds, the scaliness, the length of the peduncles, the size and division of the receptacles, the number of the fruit, and other points. All the widely diffused species exhibit a number of forms, which are in general easily referable to their respective types. The fruit is developed with more certainty where the rays of the sun have access; in the shade the frond is covered with gemmiferous cups. Both, however, grow occasionally together on the same frond.

3. Lunulariæ, *Nees*.

Sporangia seated on a common peduncle, each surrounded by a proper involucre, and splitting into four or eight valves, or irregularly torn.

487. This small tribe, like *Targionieæ*, consists of but two genera, characterised by the sporangia being at once seated on the top of the common peduncle without any distinct receptacle. An approach to this structure was already made in *Fegatella*, through which, by means of *Plagiochasma* and *Lunularia*, a direct transition is made to *Jungermanniaceæ*. The latter genus is found in several parts of Europe, including Great Britain and Ireland. It extends, however, to the Canaries and Azores, and is found again in Chili; the former appears under a single species in Corcyra, the other rather numerous species occurring principally in warm countries, and like many other sub-tropical forms, is found in New Zealand. In *Plagiochasma* (Fig. 93, *a*) there is a slight attempt at a receptacle, each lobe of which is transformed more or less into a vertical bivalved involucre, which bears at its base a shortly pedicellate sporangium, which bursts irregularly. It is divisible into two sections, of which one forms innovations at the tips, the other from the ventral side of the frond. The male fruit is in sessile lobed stellate or entire discs on the same or in different individuals. In *Lunularia* (Fig. 93, *d*), which derives its

name from the crescent-shaped processes which produce the gems, the involucres project horizontally in a cruciform manner from the top of the stem when there are four, but they occasionally vary in number from five to six. The male fruit is con-

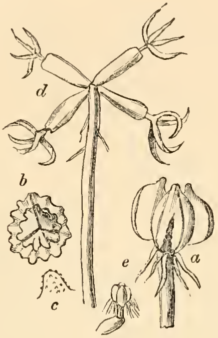

Fig. 93.

a. Plagiochasma mexicanum, receptacle, magnified. From a specimen gathered by Sallé at Cordova.

b. Spore of ditto, seen from beneath.

c. Part of margin, more highly magnified.

d. Stem with involucres and sporangia of *Lunularia vulgaris.* From Portugal, gathered by Welwitsch.

e. Young involucres taken from an unexpanded bud, with one of the basal scales reflected.*

tained in sessile receptacles situated at the lobes of the frond, which is porous as in *Marchantia.* The common stem bursts through the frond, and has a little membranous cup attached at the base, within this another cup, and within this, again, several scales.

* The tissue taken from these young sporangia contained in the involucres, resembles closely that of *Marchantia* (Fig. 92, *e*), except perhaps that the mother cells are more disposed to divide longitudinally.

III. JUNGERMANNIACEÆ, *Lind.*

JUNGERMANNIEÆ, *Nees, Endl.*

Fruit solitary. Sporangia splitting into four equal valves. Spores mixed with elaters.

488. We have hitherto had nothing in MUSCALES resembling a stem with foliaceous appendages, with the exception of *Riella* (Fig. 90, *d*), and in this case the leaf was a mere wing running round the stem. There was, indeed, a midrib in *Marchantiaceæ,* which manifested its importance by either giving rise directly to the fruit, or by the fruit proceeding from the point of bifurcation of the frond to which the midrib led, and which might be considered its point of most active vegetation. We have here, in the majority of cases, the most distinct stem with well-marked, symmetrical, often bifarious, leaves and stipules, though we begin with cases in which the frond is still as Lichenoid as before. The leaves, however, as yet assume little of the character or appearance of those of Phænogams in general. Their forms are mostly grotesque, with strange appendages, and in a few cases only assume simple, oblong, ovate, or lanceolate outlines. On the contrary, many of the strange forms assumed by the leaves of Phænogams have their counterpart among *Jungermanniæ.* Sometimes they are reduced to a few short confervoid threads, or even where the stem is developed vanish altogether ; added to which, though under certain circumstances of a pure green, they are inclined to be shaded with red, purple, chocolate, or other tints.

489. The leaves are disposed after two different plans, according to which they have received the name of succubous or incubous. In the former case they are disposed in a spiral which turns from left to right, and consequently the anterior border of each inferior leaf is covered by the posterior border of that immediately above (Fig. 94, *b*). In the latter, the spiral turns from right to left, and the anterior border of each inferior leaf covers the posterior border of the leaf placed immediately above it (Fig. 94, *a*).* Besides these there are ventral leaves,

* In Mitten's Conspectus, in the Flora of New Zealand, *Gottschea* is placed in the incubous series, for the anterior margin really goes over

called amphigastra, alternating with the others, making the arrangement $\frac{1}{3}$ of a different outline from the others, and usually less. These are sometimes called stipules, but they are not the same organs as the stipules of Phænogams. The fruit is often surrounded at the base with leaves of a different form from the other, sometimes passing through various modifications before the involucre commences. Annular threads are in many genera found in the cells of the wall of the sporangia, and broadly punctate cell-walls in their outer coat (Fig. 94, *d*).

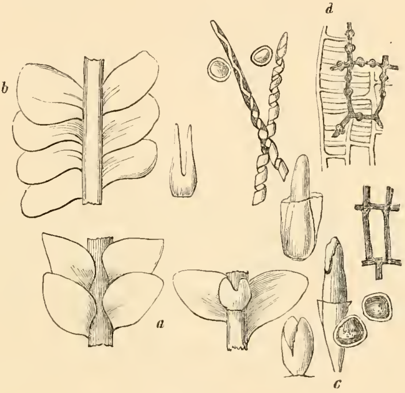

Fig. 94.

a. Incubous leaves of *Calypogeia Trichomanis*, from above and below. Moug. and Nest., No. 151.

b. Succubous leaves of *Chiloscyphus polyanthus*, with amphigastrum. Moug. and Nest., No. 436.

c. *Carpobolus orbicularis*, Schwein.* Involucre, which has lost its sporangium; sporangium with remains of calyptra and spores, and tissue of sporangium. From Hookerian Herbarium.

d. Punctate and annular tissue in the walls of the sporangium of *Metzgeria furcata*, towards the margin, with unispiral elaters and spores. All more or less magnified.

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the posterior margin of the superior leaf. A contrary view is taken by the authors of *Synopsis Hepaticarum.*

* There is no genus of Fungi named *Carpobolus;* the name of Schweinitz, therefore, ought to be retained.

490. They grow in moist shady places, on the ground, the trunks of trees, leaves, &c., and occasionally on objects exposed to the sun, provided there be sufficient moisture. Some will, however, bear considerable drought without injury. The fruit proceeds at once from the stem without any intermediate receptacle, except the point from which it springs, which is sometimes slightly swollen or depressed, and is then called the torus. It is remarkable for its almost constantly splitting into four equal valves, in which respect a close approximation was made by *Lunularia* (Fig. 93, *d*, *e*). A few exceptions will be noted as we proceed. The peduncle is surrounded at the base by various membranes, the details of which constitute the distinguishing generic characters.* In *Anthoceroteæ* there is a distinct columella, the first indication of the complication of the organs of fructification which obtain so high a development in the mosses. The spores do not produce a prothallus as in Ferns and Clubmosses, but the plant arrives at its full development before the archegonia appear, which go through the different stages of growth up to the perfect development of the spores, much after the manner of *Marchantiaceæ*, and the same plant may produce more than one crop of archegonia. The elaters, as in *Marchantia* (Fig. 92, *e*), are produced from narrow cells interspersed amongst those which produce the spores, either longitudinally or transversely, and are often permanently attached to the valves. The male fruit is variously disposed, consisting of short, often ovate, masses of cells, each of which contains a spermatozoid resembling those which have been figured above (Fig. 91, *f*). The spermatozoids were first disco-

* It may be useful to enumerate the parts which occur in *Jungermanniæ*. The sporangium is the innermost, which may be confluent with the swollen archegonium or calyptra, and is then tipped with the styleshaped summit of that organ. The swollen archegonium is, however, mostly free, and forms a distinct sac round the sporangium; in proportion as it is sunk into the torus, it bears the abortive archegonia, if more than one is present, on its surface or at its base. The perianth or proper involucre then follows, which may be more or less confluent with the calyptra. And this, again, may be surrounded by the external involucre and perichætial leaves (Fig. 95, *c*).

vered by Schmidel,* one of the most accurate of observers, and have since been often examined; they have been seen to enter the archegonia. Besides the fruit, reproductive gems occur in many species. *Jungermanniaceæ* are found in all parts of the world, but they luxuriate most in warm climates, especially in countries like New Zealand, where the temperature is tolerably uniform. Perhaps no country produces such a variety of noble species. Such delicate bodies cannot be expected to occur in a fossil state, except preserved in amber. Their qualities are but little known. A few species are highly fragrant, but I am not aware that any species answers any useful purpose to man. At present they must be regarded as objects of elegance, or as mere botanical curiosities.†

* Schmidel Icones. *Jungermannia pusilla*, tab. 22, p. 85, ¶ 5.

† The development of the spores of *Anthoceros* from the mother cells has been carefully traced out by Mohl, in Linnæa, vol xiii., p. 273; and the germination of the spores, and the development of the young plant, including *Marchantiæ* and *Lunulariæ*, by Grœnland, Ann. d. Sc. Nat., sér. 4, vol. i., p. 5. These either produce a sort of protonema or mycelium, as in Mosses, a flat or lentiform disc, or the spores themselves are transformed into little masses of cellular tissue. Sometimes the point of cell-formation is the tip of the inner membrane of the spore, protruded in the form of a thread. Both these latter modes may be exhibited by different spores of the same species.

- JUNGERMANNIACEÆ.
  - ANTHOCEROTEÆ. Sporangium 1-2-valved.
    - *Anthocerideæ.*—Sporangium threaded by the columella.
    - *Monocleæ.*—Columella, 0.
  - JUNGERMANNIEÆ. Sporangium 4-valved.
    - Frondose.
      - Frond ribless.
        - *Aneureæ.*
      - Frond ribbed.
        - *Metzgeriæ.*—Fronds forked. Involucre monophyllous, ventricose. Elaters apical, persistent.
        - *Haplolæneæ.*—Fronds bifid. Involucre short, monophyllous, or wanting. Perianth wanting. Elaters mostly parietal, deciduous.
        - *Diplomitrieæ.*—Fronds sinuate or lobed. Perianth tubular.
        - *Codonieæ.*—Fronds pinnati-partite or lamellate above. Perianth campanulate.
    - Foliose.
      - Leaves incubous.
        - *Jubuleæ.*—Elaters unispiral. Involucre of a different shape from the leaves.
        - *Platyphyllæ.*—Leaflets entire above with a folded lobe. Involucre of the same shape as the leaves.
        - *Ptilidieæ.*—Involucre thick, imbricated; fruit terminal or lateral; leaves divided; stem mostly pinnate.
        - *Cœlocaules.*—Fruit inserted in a cavity of the stem.
        - *Trichomanoideæ.*—Fruit hypogenous. Ramification irregular.
      - Leaves succubous.
        - *Geocalyceæ.*—Fruit on a distinct often succulent torus, rooting into the soil.
        - *Jungermannideæ.*—Perianth free, terminal.
        - *Gymnomitria.*—Perianth 0, or connate with the involucre. Fruit terminal.

1. Anthocerideæ, *Cord.*

Sporangium threaded by a linear columella, splitting longitudinally on one or both sides; frond without pores.

491. This tribe consists of two or three genera distinguished by the possession of a columella and by the sporangium not splitting into four, as in the greater part of the order. *Dendroceros* contains a few species peculiar to hot countries; one is claimed by Nees for the temperate clime of New Zealand, so rich in *Hepaticæ;* but this appears to be only a state of *Anthoceros lævis,* while *Dendroceros Jamesonii,* Tayl., is apparently *A. punctatus. Dendroceros* differs from *Anthoceros* in the sporangium being merely bifid at the apex, the fissure extending down one side only; but *D. crispatus* is sometimes as deeply cleft as *A. punctatus.** In *A. Jamesonii,* on the contrary, the valves adhere at the apex. *Anthoceros* proper has several species in temperate countries. Two of these occur both in the north and south hemispheres. About half belong to the tropics. *Blandovia* is a Podostemad, and has no relation to these Cryptogams. *Carpobolus* (Fig. 94, *c*) has shorter sporangia than the other genera, splitting down one or both sides, and is remarkable among *Jungermanniæ* for having no elaters. The spores are said to be fixed to thick, somewhat nodular, cords, springing from the columella. I have not been able to observe this structure in a specimen of the original species of Schweinitz, from Ohio, given to me by the kindness of Sir W. J. Hooker, probably on account of its not being sufficiently advanced. Two more species have been added by Sullivant from the same country.

2. Monocleæ, *Nees.*

Sporangium bursting by a longitudinal fissure; columella, none. Foliose or frondose.

492. No recent opportunity has offered itself for the examina- of *Monoclea,* in which, as Sir W. J. Hooker himself says, the columella may have been overlooked. As, however, it is equally possible that none may have existed, and as there is another genus, *Calobryum,* destitute of a columella, it is well

* See Fl. of New Zealand, p. 171.

to retain the tribe. It consists of but two genera of very different habits. *Monoclea* has the habit of *Anthoceros*, having a horizontal frond; *Calobryum* has a creeping primary stem, with erect branches, clothed with obliquely obovate, entire, vertical leaves. The sporangium is about two lines long, splitting on one side only.

3. ANEURIÆ, *Nees, Endl.*

Fruit marginal, ventral; involucre lobed or torn; perianth none; archegonium adnate with the torus; sporangium oval or oblong, four-valved; elaters unispiral, attached to the tips of the valves; frond fleshy, palmate, or pinnatifid, destitute of any nerve.

493. We begin here the frondose four-valved *Jungermanniæ*, distinguished by the jagged margin, and the nerveless fronds. Their favourite place of growth is the margin of ponds, the base of overhanging rocks, or other situations, where they do not receive the direct light of the sun. In such situations two or three species are extremely common. The tribe contains but one genus, *Aneura*, almost equally distributed between the temperate regions and the tropics; and of the European species, two or three are almost cosmopolitan. In all probability the species are far too greatly multiplied, for, as regards size, and the outline of the frond, they vary extremely. The elaters remain for a long time attached to the tips of the valves, which are often ornamented with a pencilled appendage arising from the inner membrane.

4. METZGERIÆ, *Nees, Endl.*

Fruit ventral, springing from the midrib; involucre monophyllous; perianth none; archegonium rather thick; sporangium ovate; elaters unispiral, attached to the tips of the valves; fronds ribbed, forked.

494. This tribe consists, like the last, of but a single genus, and is distinguished mainly by the presence of a midrib in the frond, and the forked division. They grow more frequently on trees, rarely on the ground. Of the two British species, *M. furcata*, a very variable plant, is perfectly cosmopolite, occurring in both hot and cold regions in either hemisphere, and *M. pubescens* (remarkable for its pubescent frond) is found in the

Nilgherries and the Straits of Magellan. Of the other species some are tropical, while others, as *M. eriocaula* (Fig. 4), belong to the more equable temperate regions. This is referred by Mitten, together with *M. prehensilis* and *Aneura multifida*, to *Sarcomitrium*. The tribe would, perhaps, be better united with *Haplolæneæ*.

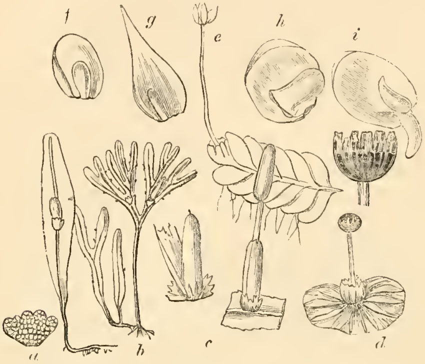

Fig. 95.

a. Symphyogyna subsimplex, nat. size, with scale-shaped involucre slightly magnified.

b. Symphyogyna hymenophylla, nat. size. Both from the Hookerian Herbarium.

c. Blyttia Lyellii, sporangium bursting through the two involucres, and the involucres laid open, so as to show the archegonium or calyptra *in situ*, with two or three abortive archegonia at the base. From a specimen gathered in Louisiana by Drummond.

d. Petalophyllum Ralfsii, nat. size, and sporangium magnified. From a specimen received from Mr. Ralfs.

e. Androcryphia porphyrorhiza. After Montagne, in Ann. d. Sc. Nat., Juil. 1839.

f. Leaf of *Frullania aterrima*, magnified.

g. Ditto of *F. aculeata*.

h. Ditto of *F. incumbens* (lobes open below).

i. Ditto of *F. cornigera* (lobes open above).

The two first from the Hookerian Herbarium, the two latter from Flora of New Zealand.

5. Haplolæneæ, *Nees.*

Involucre monophyllous when present, jagged; perianth none; sporangium sphærical; elaters bispiral, seated near the base, and deciduous, or attached to the apices of the valves; fronds dichotomous, ribbed, or with the rib confluent with the margin.

495. This tribe consists of three genera, of which *Blasia* and *Pellia* contain common European forms, while *Symphyogyna*, though extending to Australia and New Zealand, is entirely extra-European. *Pellia epiphylla*, which affects the same situations as *Aneura*, is known by its dorsal fruit, and globose sporangia, the elaters of which do not adhere to the tips of the valves. *Blasia* has scarcely any involucre, and is remarkable for the flask-shaped bodies which contain the gems, and which may easily be taken for fruit. *Symphyogyna* (Fig. 95, *a*, *b*) contains many very beautiful forms, some of which are erect and stipitate, from a creeping rhizoma, and appear like little *Hymenophylla*. In this genus the valves of the sporangium often adhere together above, like those of *Andræa*. *S. rhizobola* has a strongly nerved frond, with a thick serrated margin, and often ends in a filiform rooting process like the stem. The involucre in *Symphyogyna* consists of a single scale. The archegonium after impregnation extends downwards into the torus, so that when it is fully developed, and the sporangium bursts out, it is studded above with the abortive archegonia. New Zealand produces five species, two or three are found in New Holland and Tasmania, and one doubtful species in North America.

6. Diplomitrieæ, *Nees.*

Diplolæneæ, *Dum.*

Involucre monophyllous, at first terminal, arising from the midrib, ventral or dorsal; perianth tubular; sporangium oval or oblong; elaters deciduous, frondose, costate.

496. This tribe contains but a single genus, *Blyttia* (Fig. 95, *c*), which is represented in Europe by two species, of which one, *B. Lyellii*, occurs in almost all parts of the world. Three species are found in New Zealand, one at Cape Horn, and one

in St. Helena. *Blyttia* is distinguished by a general and proper involucre. The male organs are accompanied by scattered or crowded toothed perigonial scales. The elaters are at first attached to the inner surface of the valves, and at length deciduous. *Blyttia Lyellii* is one of our most interesting *Jungermanniæ*. *B. Phyllanthus* resembles in habit *Symphyogyna subsimplex*, but the fruit is very different. This latter is, however, separated by Mitten under the name of *Podomitrium*, on account of the ventral involucre and pedicellate male spikes. In *Blyttia*, the anthers are dorsal and imbedded on each side of the nerve. Like *S. subsimplex*, *Podomitrium* grows on tree-ferns.

7. CODONIEÆ, *Dumort.*

Fronds pinnatifid, the divisions leaf-shaped or lamellate above; perianth large, campanulate.

497. This tribe conducts us by slow degrees through *Fossombronia*, to the truly leafy *Jungermanniæ*, which form the vast mass of the order. *Zoopsis*, however, which occurs in several places in the southern hemisphere, makes no approach to the more leafy *Jungermanniæ*. It is remarkable for its silvery, often cylindrical, rigid frond, resembling some zoophyte, without any trace of a border, and consisting of large cells, built round a central axis. *Petalophyllum* (Fig. 95, *a*) has fronds with gill-like folds above. *P. Ralfsii* is a most interesting species, and remarkable for its sporangium being valveless. The sporangium rises from a broad bell-shaped perianth; its surface is curiously tesselated in consequence of the outer coat being less extensible than the inner. The spores are reticulated and resemble those of a truffle. The elaters have two and sometimes three spires, and are often forked. *P. Preissii* is an Australian species. In this the folds sometimes assume the form of leaves, especially on the young shoots. *Androcryphia* (Fig. 95, *e*) has one Brazilian and one antarctic species. Like *Fossombronia*, it has distinct distichous succubous leaflets, but differs in its regularly quadrivalve sporangium, bilobed perianth, and immersed antheridia. *F. pusilla* is a widely distributed species, occurring both in the north and south hemispheres; the others are all species of warmer climates than our own.

8. JUBULEÆ, *Nees.*, *Endl.*

Valves of sporangium reaching only to the centre; elaters unispiral; perianth regular, divided above; involucre of a different shape from the leaves; leaves lobed or folded below.

498. The last tribe has brought us by gentle degrees to the vast mass of leafy *Jungermanniæ.* The tribes hitherto have contained but few species: a single genus alone in the present, *Frullania*, contains considerably more than a hundred, while *Lejeunia* has twice that number. Far the greater part of the species belong to the tropics, or to those temperate regions which display tropical forms. *Lejeunia* and *Frullania* together have scarcely more than a dozen European representatives; of these *Lejeunia serpyllifolia* and *Frullania tamarisci*, especially the latter, are almost universally distributed. *Frullania* has sixteen species in New Zealand, while *Lejeunia* has seventeen. The perianth is mostly ribbed or angular, with the angles frequently ciliated, sometimes merely compressed. The leaves have always a lobe at the base, variously convolute, saccate, &c.; and sometimes, as in *Frullania*, between the sac and the stalk there is a style-shaped process or triangular fold, an exaggeration of which appears in *F. cornigera* (Fig. 95, *i*). The cells of the inner wall of the sporangium do not contain any annular fibres, and the peduncle is often nodular when dry, from the contraction of the body of the prismatic cells of which they are composed. All the genera, except *Frullania*, have but a single archegonium. In *Frullania* there are from two to four. *Phragmicoma*, which is represented in Ireland by *P. Mackaii*, is distinguished from *Lejeunia* by its compressed perianth. *Lejeunia* differs from *Frullania* in its single archegonium, its connivent valves, and in the less complicated leaves. Mitten is inclined to unite most of the other genera with *Frullania*, and I think rightly. *Bryopteris* is remarkable for its superior size to most *Frullaniæ* and hypnoid aspect.

9. PLATYPHYLLÆ, *Nees.*

Perianth campanulate or subcylindrical, not winged or angular, more or less depressed, bilabiate; involucre of the same shape as the leaves; archegonia numerous; sporangium split almost to the base; elaters bispiral; leaves with a folded lobe at the base.

499. This tribe is known by the lobe at the base of the leaves being simply folded upon the larger lobe. In *Radula* it sends out fine roots into the soil; in *Madotheca* it is smooth. We have lost here the winged and angular perianths of *Jubuleæ*. *Madotheca platyphylla* is one of our commonest species, forming elegant tufts on walls. It assumes a great variety of forms, and is common in the United States. *Radula complanata* is scarcely less common on trunks of trees; neither, however, is confined to one habitat. There are a few other representatives, but the greater part of the species belong to the tropics, or warmer temperate regions. Gems are formed on the margin of the perichætial leaves in *R. complanata*. The leaves are generally entire, but they are sometimes fringed or toothed.

10. Ptilidieæ, *Nees.*

Mastigophoreæ, *Nees, Endl.* Ptilidia, *Nees.*

Perianth often confluent with the involucre; involucre polyphyllous, imbricated; stem mostly pinnate; leaves divided.

500. This tribe contains many beautiful species, the greater part of which belong to the tropics. *Ptilidium ciliare* is a common subalpine species, remarkable for the long setaceous cilia of the leaves; the perianth is still free. *Polyotus* is an antarctic genus in which the perianth is wanting, the leaves are lobed somewhat after the fashion of *Frullania*, and some of the stipules have saccate lobes. *Sendtnera* has a few European species; the branches are often much attenuated at the tips and recurved, which gives them a peculiar appearance. There is a perianth as well as an involucre. *Sendtnera diclados* (Fig. 96, *d*) affords a good example of the thick walled tissue with connecting ducts, which occurs in many *Jungermanniæ*, as *Jungermannia Turneri* and *Sendtnera Woodsii*, to which attention was first called, I believe, by Sir W. J. Hooker, as different from the ordinary cellular tissue of the leaves of *Jungermanniæ*. *Trichocolea* has a bristly involucre, and palmatifid leaves, which are, moreover, so finely divided that they appear woolly. *T. tomen-*

tella is not an uncommon English species, and is, indeed, almost cosmopolitan; but it is far surpassed by *T. lanata* (Fig. 96, *e*), which looks like a tangled worsted thread.

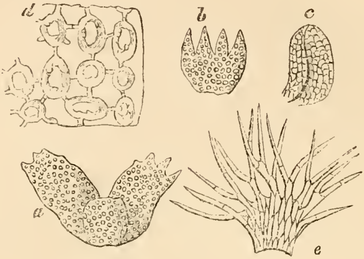

Fig. 96.

a. Leaves and stipule of *Mastigobryum cordistipulum.*
b. Leaf of *Lepidozia lævifolia.*
c. Ditto of *Micropterygium nutans.*
d. Tissue of *Sendtnera diclados.*
e. Stipule of *Trichocolea lanata.*
All more or less magnified. From specimens in the Hookerian Herbarium.

11. Cœlocaules, *Nees.*

Fruit inserted in a hollow of the stalk; leaves incubous, folded, bifid, crested.

501. This tribe includes some of the finer species, which are known by their large size and apparently double row of succubous leaves. Almost all belong to warm or equable climates, and are found both on the ground and on the trunks of trees, principally in the southern hemisphere. There is no perianth, the functions of which are performed by the hollow in the stem, in which the sporangia are sunk. This arises from the outer wall of the stem being carried up when the archegonium is impregnated. The calyptra bears on its surface the unimpregnated archegonia, as we have seen in *Symphyogyna*,

p. 452. There are two distinct sections, in one of which the leaves are simply folded, as in *Scapania;* in the other, the dorsal lobe is often less, and placed upon the back of the inferior lobe. The involucre varies in character, being sometimes tubular, sometimes foliose. In *S. pinnatifolia* and *lamellata* the upper part of each half leaf is pinnatifid. Mitten puts them rightly amongst the incubous species; and the correctness of this view is confirmed by *Physiotium*, with which they agree in habit.

12. Trichomanoideæ, *Nees, Endl.*

Fruit hypogenous, sessile or seated on a ventral branchlet; perianth mostly present; sporangium split to the base; leaves incubous, seldom auriculate.

502. This is the last tribe of the incubous leaved *Jungermanniæ*, far the greater part of which are extra-European. The large genus *Lepidozia*, for instance, has but two, and *Mastigobryum* the same number of European representatives. Many, however, descend to the southern regions. They are principally distinguished by their hypogenous fruit, which rises at once from the stem or from a short branchlet. *Physiotium* and *Micropterygium* have little lobes; the greater part of the species have simple leaves. The branches often end in flagelliform elongations, like those of *Sendtnera*. *Physiotium cochleariforme*, which grows in turfy spots in alpine districts, is one of our finest species, but it rarely bears fruit. *P. sphagnoides*, a magnificent form, has quite the habit of *Gottschea*. *Micropterygium* has keeled leaves, but the character is scarcely conspicuous in *M. nutans** (Fig. 96, *c*). *Mastigobryum* exhibits various forms of leaves, frequently notched or emarginate above (Fig. 96, *a*); the stipules are sometimes continuous with the leaves. *Lepidozia* is distinguished from this principally by the greater division of the leaves (Fig. 96, *b*) and plicate calyptra. *L. reptans* and a closely allied species are the only British species. *Calypogeia*

* I do not find the leaves bifid in specimens from the Hookerian Herbarium; and since they are not constantly so, the characters of the plant approach still nearer to *Micropterygium*, in which Mitten places it, instead of *Mastigobryum*.

Trichomanis (Fig. 94, *a*) is a well-known indigenous species, and forms a transition to the next group by its fleshy subterraneous involucre.

13. Geocalyceæ, *Nees*.

Fruit immersed in a branchlet, or the saccate tip of the stem which is often fleshy; perianth wanting or confluent with the torus; leaves succubous.

503. We come now to the division with succubous leaves. We have just had in *Calypogeia* a direct transition, in the absence of a perianth and the subterraneous involucre. All the species belong to the southern regions, or to the warmer parts of Europe, except *Geocalyx contortuplicatus*, which comes from St. Domingo, *Geocalyx graveolens*, remarkable for its dis-

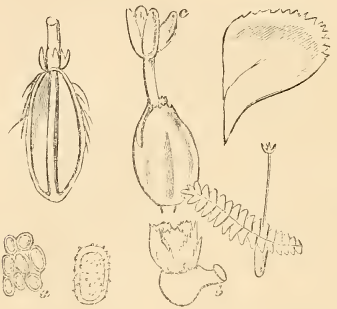

Fig. 97.

a. Saccogyna australis, tissue of leaves and section of hypogæous torus, showing the involucre above. The latter from the Flora of New Zealand. More or less magnified.

b. Saccogyna viticulosa. Plant nat. size, with torus and involucre.

c. Plagiochila Stephensoniana, perianth and single leaf, magnified. From Flora of New Zealand.

agreeable smell, which ascends as high as Pomerania and Sweden, and *Saccogyna viticulosa*, which is found in Great Britain. *Saccogyna australis* agrees closely with this; but whereas in the former the calyptra is adnate for three-fourths of its length with the hollow torus, in the latter it is entirely adnate. The tissue of the leaves has large intercellular passages, and is minutely echinulate. In *Geocalyx graveolens*, I find the same loose cells, but no echinulations. *Gymnanthe setulosa* is remarkable for its hispid stem.

14. Jungermannideæ, *Nees*.

Perianth free, terminal, herbaceous, generally exserted, sometimes concealed by the involucre, but in that case distinct; leaves succubous.

504. This tribe contains the large mass of the succubous leaved *Jungermanniæ*, and a great many of the finer species, approaching in size some of the smaller Ferns, and resembling them in their filmy aspect. They are found in all countries; but nowhere, perhaps, do they luxuriate so much as in New Zealand. The greater number of species occur in the tropics. *Jungermannia* alone has its maximum in Europe. *Plagiochila* contains a hundred species, while *Jungermannia* has nearly half as many more, and *Chiloscyphus* nearly fifty. Their succubous leaves and free perianths are their distinguishing marks. Few Cryptogams exceed in beauty some of the *Plagiochilæ*, and we are not without one fine species, *P. asplenioides*. *Sphagnocetis communis* is found very commonly amongst *Sphagnum*, creeping by means of long flagelliform radical fibres; the cells of the leaves are round and quite distinct from each other, with large intercellular spaces. *Chiloscyphus* has a short deeply cleft perianth, often shorter than the calyptra. *Lophocolea* has crested perianths. *Liochlæna lanceolata* has the perianth arched and remarkably truncate. In *Jungermannia* proper, it is plicato-angular above and cleft; in *Scapania*, even, compressed above and below, with folded leaves; while in *Plagiochila* it is bilabiate, and laterally compressed.

15. Gymnomitria, *Nees*.

Perianth wanting, or connate with the involucre; calyptra surrounded by the involucre; leaves succubous.

505. This tribe contains the few remaining genera of succubous *Jungermanniæ*, which, with one or two exceptions, are

European or southern species. India and Java have their representatives, but they are not in general cosmopolites. As the name expresses, the distinguishing character is the absence or slight development of the perianth. In *Alicularia*, however, the toothed edge is free. *A. scalaris* is a common species upon loamy soil, in woods and waste places. The calyptra is shorter, and surrounded at the base by abortive archegonia. *Sarcoscyphus*, also, has the edge of the perianth free, and the stem, though at first creeping, becomes erect at the tips. *S. Ehrarti*, the old *Jungermannia emarginata*, is a common Alpine British species. Sir W. J. Hooker, in company with Mr. Borrer, found examples with two or even three sporangia in the same involucre, a very uncommon circumstance. *Acrobolbus Wilsonii*, which was found near Killarney, resembles *Geocalyx* in its descending radiculate involucre, but is distinguished from similar productions by its succubous leaves. *Gymnomitrium* has no perianth, unless it be the inner membranous leaf of the involucre, which conceals the calyptra. *Haplomitrium*, on the contrary, has the calyptra longer than the involucre, without any perianth. The only species, *H. Hookeri*, is classical, from the excellent memoir of Gottsche, illustrative of it, in Act. Ac. Cæs. Nat. Cur., vol. xx. The involucre itself is scarcely developed, or differentiated from the other leaves. Some of the upper leaves have retort-shaped cells attached to the margin, which may possibly be reproductive.

506. The limits of the species of *Jungermanniæ* in general, are at present very imperfectly understood. It is quite certain that many *Frullaniæ* must be reduced, and the same may be said of other species belonging to prolific genera. It is at least clear that many of the commonest species are subject to great variations as regards size, colour, length of the peduncles, the form of the leaves, their closer or denser arrangement on the branches, and even in the appendages on their lower margin. Fruit is comparatively so rare, that we cannot always appeal to it, its place being supplied by reproductive gems. The serration of the leaves, again, is extremely variable, sometimes occurring only on the upper limb, sometimes

confined to the lower in the same species. The amphigastria also differ much in size, number, and arrangement. In fact, the characters are so variable that the student must be prepared for great differences, and must not suppose that slight distinctions are sufficient for the proposition of new species. One or two incubous *Jungermanniæ* occur in amber.* These are, I believe, the only certain traces of such plants in fossil remains.

IV. Musci, *Juss.*

Bryaceæ, *Lindl.* (exclusis *Andræaceis*).

Sporangia valveless, or very rarely valvate with the tips of the valves free or adherent, opening for the most part by a definite horizontal fissure, the mouth of which is naked or fringed with various appendages, mostly definite in number. Elaters, none. Calyptra parting at the base, and carried up by the peduncle, or very rarely ruptured in the midst. Leaves simple, mostly regular; cells sometimes containing a spiral thread. Fruit often furnished with true stomates. Antheridia on the same or on different plants from the sporangia.

507. The vast mass of Cryptogams known under the name of mosses, is with few exceptions at once distinguishable to the naked eye from *Hepaticæ*, even in the absence of fruit. For the leaves are not only regular in outline, but there is far more variety in their spiral arrangement, and even in those cases where they are distichous and filmy, there is a peculiar indefinable aspect about them which is seldom deceptive. If the determination is easy at first sight in the absence of fruit, the facility is greatly increased when this is present. In one small tribe alone is there any approach to the valvate sporangia, which have been with such rare exceptions present in *Hepaticæ*. Moreover, in one case alone of *Marchantiaceæ* have we seen anything in the shape of peristomal appendages to the sporangia, with the exception of the elaters, which belong to a totally different category; whereas in mosses, except in a few simple cases, they are universal. Though occasionally,

* See Gæppert, Organische Reste im Bernstein.

when exposed to the sun, especially where abundant moisture is present, in some genera the leaves acquire brown, red, or other tints, they are by no means so subject to assume abnormal tints as *Jungermanniæ*. Though, again, many mosses have creeping stems, they are far more apt to be erect than *Jungermanniæ*, or to make pulvinate tufts.

508. Mosses, like *Hepaticæ*, are propagated by gems and spores. The former grow in various situations; sometimes on distinct organs, sometimes at the tips of the nerves (Fig. 100, *b*), and sometimes they are generated on the rootlets which grow in various parts of the plant, and in many species form a dense woolly or silky mass, which is mostly of a bright yellow brown, varying to nearly pure tints, and sometimes purple.

509. The spores of mosses on germination form a confervoid mass, which has often been considered, without any reason, a sort of cotyledon. This mass is very much of the same nature as the mycelium of Fungi, and is called the Protonema, and is always distinguished by the cells containing chlorophyl. Many spores may concur in the formation of this mass; but whether more spores than one concur in the formation of a single plant, is doubtful. Be this as it may, after a time a little knot or swollen articulation appears upon the threads, which, by cell-division, is developed into a leafy shoot, which may be annual or of longer duration. Archegonia appear at different points, according to the particular species, and antheridia, consisting of masses of cells accompanied by jointed paraphyses. At the base of each archegonium is an embryonic cell, which, by cell-division, gives rise, after a time, to a perfect sporangium. The archegonium swells as well as the sporangium; but after a time, by the elongation of the peduncle, it is forced from its connection with the stem, or that continuation of the stem which has been called the vaginula, and is carried up by the sporangium, where it forms a veil, which, if split on one side, is said to be dimidiate; if split in several points or entire, it is said to be mitriform, campanulate, &c. In one or two cases the calyptra bursts in the midst, as the sporangium swells, without being at the same time carried upwards from the want

of a peduncule. In general one archegonium only is impregnated, and then the abortive archegonia are scattered over the vaginula, or borne on the walls of the calyptra. The sporangium itself is usually more or less elliptic, with the sides occasionally grooved or compressed. It is almost always borne on a peduncle of greater or less length, which may be sunk in the receptacle, or otherwise. In some cases, as in *Sphagnum*, the apparent peduncle is the elongated stem. The sporangium itself consists of a central cylindrical or more or less deeply winged columella, with which the spores are in contact; and a wall immediately confining the spores, which is in most cases attached by filaments to the outer wall. In *Sphagnum*, however, the spore-sac and outer wall are confluent. In a few *Phasca* alone the columella is absent or imperfect. The spore-bag is usually called the sporangium, and the whole fruit, the theca; but if the fruit in *Jungermanniæ* be a sporangium, that in mosses is perfectly homologous. The sporangium has often a swelling at the base, which is called an apophysis. It opens above by a definite circular fissure, so as to throw off a little lid or operculum, which often remains attached to the inside of the calyptra, and sometimes, as in *Wardia*, to the columella. In a very few cases only there is no separation. At the point of separation there is often a deciduous ring. The separation of the lid may at once expose the spores; they may, however, be covered with a membrane, entire or toothed at the circumference; or there may be one or two rows of teeth surrounding the aperture, which are not fewer in number than four, and if more, some multiple of that number.

510. The teeth arise from the thickening of the cell-walls of two contiguous cells, and if there is a second row of teeth the next two cell-walls towards the centre are thickened. In some cases, as in *Barbula* (Fig. 98, *a*), two or more distinct elevations are formed, instead of a uniform thickening, and if one or three elevations be formed instead of two, the normal number of teeth is disturbed. The outer row of teeth arises frequently from the innermost layer of cells of the outer wall, the inner from the outermost layer of the spore-sac; but this is not positively constant, and where the peristome is double,

three strata of cells are requisite to form the teeth (Fig. 100, *a*).

511. It has been attempted to be shown that these teeth, like petals, are modifications of leaves; but there is no reason to believe that this is the case. They have never been seen transformed into leaves, nor does their origin agree in the least with that of leaves. The cases in which it has been reported

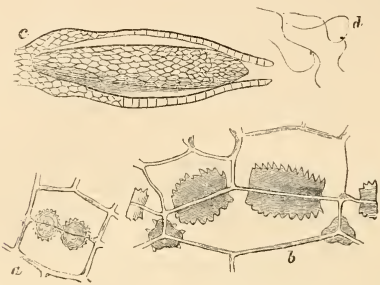

Fig. 98.

a. *Barbula fallax*, horizontal section of two cells, on the contiguous walls of which two teeth are formed.

b. *Orthotrichum affine*, ditto of the three cells from which the outer row of teeth and the alternating cilia are formed. Both after Lantzius Beninga.

c. Archegonium and young sporangium of *Phascum cuspidatum*, after Hofmeister.

d. Spermatozoids of *Funaria hygrometrica*, after Thuret.

that the columella has extended beyond the sporangium clothed with leaves have rested on imperfect observations. The teeth, indeed, are not organs developed on the walls, but mere modifications of particular strata of cells, which enter into the composition of a body which was at first solid. The cavity of the sporangium is not, in fact, comparable with the hollow receptacle of *Rosaceæ*, which it ought to be if the peristome consisted of leaves. The mode of development of the different parts of the sporangium followed out from the beginning, shows that the view cannot be correct; and even supposing the peduncle might produce a leafy shoot instead of a sporangium, a matter very easy to conceive, the external leaves would bear no relation to the internal teeth.*

512. The spores are not attached, and are without elaters. The mother-cells usually divide into four; but in *Eucamptodon perichætialis* (Fig. 99, *e*) the division goes still further, and the spores appear not to separate when mature. The spores are in general confined to the space between the membranous wall of the spore-sac and the columella; but occasionally some of the cells of the inside of the columella itself are converted into spores, as in *Syntrichia subulata*.† In some *Polytricha* the columella is attached by threads to a waved membrane, in the central layer of which the spores are generated. The inner membrane of the spore-sac in other cases does not, therefore, properly belong to the columella. The top of the columella, which is a prolongation of the axis, and which dries up after it has performed its function of nourishing the seed, sometimes forms a sort of membrane, which closes the mouth of the sporangium, as in *Polytrichum*, and sometimes, as in *Dawsonia*, is resolved into threads, while in *Tetraphis* it splits conformably with the pseudo-peristome.

513. The genera depend mostly on the nature of the peristome, and other details of the fruit. If the plant is annual or biennial, it dies after bearing fruit; but if perennial, two or more successive crops of archegonia appear. The mode of fructification, therefore, resembles that of Phænogams with this great difference, that impregnation in the latter produces a young plant from each embryonic cell, while in mosses the impregnation of one embryonic cell produces a sporangium containing a multitude of reproductive bodies, which have no trace of cotyledons or axis. The elaters in *Hepaticæ* arose from the development of cells mixed with the mother-cells of

* See, however, the contrary opinion ingeniously maintained in Lindley's Vegetable Kingdom, p. 65.

† Lantzius-Beninga, l. c., tab. 58, fig. 9*.

the spores; in mosses the cells which do not produce spores are abortive. The spermatozoids are produced exactly as in *Hepaticæ,* and have the same form. In phænogams the germen is produced before impregnation. It is obvious that no sporangium can be produced in mosses without impregnation, as the whole depends upon one embryonic cell. Without some system of propagation by gems, many diœcious species would soon die out, in consequence of the rarity of fructification.

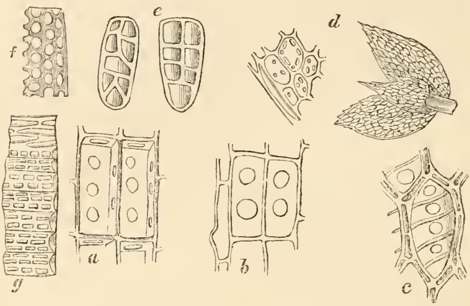

Fig. 99.

a. Portion of leaf of *Octoblepharum albidum,* from specimens collected by Cuming, seen from above.

b. Ditto of *Leucobryum glaucum,* seen from the inner side, with the intermediate cells.

c. Ditto of *Sphagnum latifolium,* seen from above.

d. *Hypopterygium Smithianum,* showing the distichous leaves and stipules, with a portion of the edge of the leaf. From a Norfolk Island specimen in the Hookerian Herbarium.

e. Permanent mother-cells of *Eucamptodon perichætialis.* From a specimen given me by Dr. Montagne.

f. *Andræa subulata,* portion of leaf from Cape of Good Hope. From Hook. Herb. (The light parts, however, ought not to look like perforations.)

g. *Campylopus lamellinervis,* under side of nerve. From Hook. Herb.

All more or less magnified.

514. The leaves of mosses, as regards at least the lamina, usually (Fig. 98, *d*) consist of a single stratum of homologous cells as in *Jungermanniæ,* but this is by no means constant.

In *Sphagnum* and *Leucobryum*, there are two sets of cells, the one filled with chlorophyll and very narrow (Fig. 98, *b*), the other colourless. The walls of these have large round perforations, which in *Sphagnum* occur on the external wall, as well as the others, while in *Leucobryum* (Fig. 99, *b*) they are confined to the inner walls. In *Octoblepharum* there are similar apertures, and in *Leucophanes* I find them at the two extremities of the cells. In several white mosses there is more than one layer of cells. In *Leucobryum* the narrow cells are imbedded amongst the colourless cells, but in *Sphagnum* they are interstitial, so as in a direct view completely to surround them. The leaves have often one or more nerves consisting of elongated tissue, which when single may reach the tip of the leaves or not, and run out in the form of bristles. The margin is often serrated and thickened. The surface is usually even, but occasionally rough with points. In *Polytrichum* the upper surface of the nerve is lamellose ; in *Campylopus*, the lower surface ; while in *Pottia* the laminæ are confined to a portion only of the upper surface. The leaves are variously arranged, more frequently, however, so as to form cylindrical masses of greater or less length, than flattened strap-shaped branches. They very rarely have anything like stipules; but in *Hypopterygium* (Fig. 98, *d*) there is decidedly the same formation as in *Jungermanniæ* ; while in the equitant leaves of *Fissidens* there is a close resemblance to the folded keeled leaves of *Gottschea*. I am not aware that stomates occur on the leaves, but true stomates are found on the female fruit of most mosses.* Unrollable spirals occur in the calyptra of *Mnium hornum*, according to Schimper.

515. The species of mosses are extremely numerous, and many of them very widely distributed, though there are a great many purely tropical or sub-tropical forms and genera. Species which are too delicate for the temperate regions of the northern hemisphere, extend sometimes through the whole of South America to the Southern Islands. At the same time many are able to endure very low temperature without injury;

* Valentine in Linn. Trans., vol. 18, p. 239.

and some of the very finest forms, as the larger *Splachna,* are found in high northern latitudes, where, however, the heat of the short summer is often considerable. A very few only of the tribes are excluded from Europe. Particulars will be given under the respective tribes. They grow in all kinds of situations, and a few flourish where very little light penetrates. Many luxuriate under water, but seldom fructify. A few

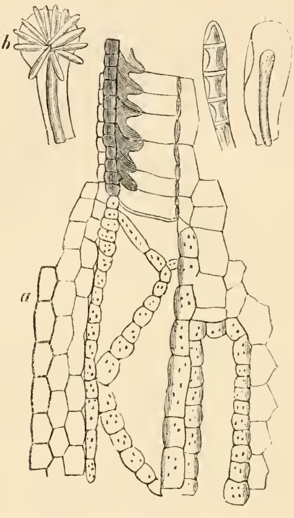

Fig. 100.

a. Vertical section of the sporangium of *Aulacomnion palustre,* after Lantzius-Beninga, to show that the outer row of teeth arises from the inner layer of the cells, which constitute the outer wall of the sporangium, and the inner row from the outer layer of the spore-sac. This, it should be observed, is connected with the outer wall by threads traversing the intermediate cavity. It will be seen that the teeth in either case are formed by the thickening of the walls of two contiguous cells.

b. Tip of leaf of *Calymperes Afzelii,* with gems attached to the end of the nerve. In *Calymperes rigida* the gems are attached to the very tip of the leaf. After a sketch in Hook. Herb.

mosses have been found in amber; otherwise there are no certain traces of them in fossil remains.

516. The uses of mosses are for the most part unimportant, *Polytrichum*, however, supplies mats, brooms, and other implements. *Dicranum condensatum*, with its confervoid rootlets, is used by the Esquimaux for lamp-wicks. A few species are excellent for packing or caulking wooden structures; while *Sphagnum* supplies materials for mattrasses; and the Laplanders use it instead of clothes for their new-born babes. *Polytrichum* was formerly considered diuretic, and *Sphagnum* sometimes enters into the composition of bread in Lapland. In the economy of nature they form an important part, constituting often the first vegetation on exposed soil, while *Sphagnum* by its rapid growth contributes greatly to the formation of peat mossses, and almost all the species act upon the atmosphere in the same way as Phænogams.

517. The arrangement proposed by Montagne, in his admirable article in Orbigny's Dictionary, is that which I shall principally follow in the short remarks I have to make on the structure of the different groups. It does not profess to be perfect; but it is perhaps the best adapted for the student, and is almost identical with that adopted from Bruch and Schimper, in the last edition of the Muscologia Britannica.*

518. Mosses are divisible into five principal groups, of very different comparative magnitudes: Those whose sporangium splits into valves, like *Jungermanniæ;* species with fasciculate branches; those in which the fruit terminates the principal divisions of the stem; those in which it is seated on short special branches; and finally, those in which it is lateral, whether on the stem or branches.

MUSCI.	*Schistocarpi.*—Fruit splitting into valves.
	Syncladei.—Branches fasciculate.
	Acrocarpi.—Fruit terminal.
	Cladocarpi.—Fruit terminating short special branchlets.
	Pleurocarpi.—Fruit lateral.

* Bryologia Britannica, by William Wilson, 1855. This work is conducted throughout on the most accurate scientific principles, and no single page of it can be consulted without profit.

I. Schistocarpi, *Mont.*

Musci schistocarpi, *Brid.*

1. Andræaceæ, *Lindl.*

Sporangium sessile on the elongated receptacle, split into four or more valves, which are either connected above by the operculum or are perfectly free. Elaters, none.

519. In external characters this tribe bears a close resemblance to *Jungermanniæ*, and there is even some resemblance to what is called the dotted leaves of certain of that race of *Hepaticæ* (Fig. 99, *f*); but the cells are not connected together by tubes in the thick walls, nor are the leaves disposed after the same fashion; besides which, there is a distinct columella. They are, in fact, as decided mosses as any, in spite of their

Fig. 101.

Sporangium of *Acroschisma Wilsoni*, from Hookerian Herbarium. Magnified.

valvate sporangia. In most species the valves adhere to the operculum, but in *Andræa Heinemanni* they are free. This species is, moreover, remarkable for the apophysis or swelling at the base of the sporangium. In this genus, as in *Sphagnum*, the stem is elongated, forming a sort of filiform receptacle to the vaginula, so that the sporangium, though really sessile, appears as if it were pedunculate. The calyptra, moreover, bursts irregularly, though it is somewhat mitriform.

520. All are of a dark or dingy green. The common European species, as *A. alpina* and *rupestris*, are widely distributed, and not only occur in the southern hemisphere, but in intermediate tropical stations. The southern hemisphere produces several peculiar species, and there are, besides, one or two tropical representatives. *Acroschisma*, an antarctic genus (Fig. 101), has the sporangium cleft only part of the way down; the valves vary in number, and the fruit when young is involved in the oblong membranous base of the calyptra, so as to have an aspect very closely resembling that of some *Jungermanniæ*.

II. SYNCLADEI, *Berk.*

Branches fasciculate.

521. It seems so contrary, not only to distinctive characters, but to natural affinity, to place the cladocarpous mosses of which this division is composed, amongst the *Acrocarpi*, while they are still farther removed from their nearest allies when associated with *Mielichoferei*, that I feel myself constrained to propose a distinct division for their reception, without, however, considering them, with some authors, as belonging to a distinct natural order. They have, indeed, such peculiar characters, that in many respects they stand apart from most other mosses, and are certainly more nearly allied to *Andræacei*, than to any others. They are mere analogues of the *Leucobrya*.

1. SPHAGNEI, *Mont.*

Sporangium globular, seated upon the top of the turbinate pedunculate vaginula, within which is a very short peduncle. Peristome none. Calyptra ruptured near the middle, persistent below. Spore-sac extending over the top of the abbreviated columella. Leaves white; cells perforated, surrounded by narrow chlorophyll cells. Antheridia globose, pedunculate.

522. The white perforated leaves, accompanied by narrower cells, containing chlorophyll (Fig. 99, *c*), are not without example in other tribes; the sessile sporangia and calyptra, bursting in the centre, have their parallel amongst *Andræacei;*

but the fasciculate branches are different from what is found amongst any other mosses. The narrow cells of the leaves are derived from the tissue of the stem, the larger cells being formed independently in the meshes of the net-work. Their outer wall is perforated, which is not the case in those other white-leaved mosses, which agree with them in structure. Another peculiarity is the total absence of roots; and still another, the resemblance of their globose pedunculate antheridia to those of *Jungermanniæ*. *Sphagna* live in boggy places, where they grow with great rapidity, soon filling up inequalities in the surface, and forming a spongy, almost indestructible mass, which affords a fitting soil for many Cryptogams and Phænogams. The peat, however, which is thus formed, is useless, from its soft spongy texture, for fuel. "In this division," says Mr. Wilson, "the leaves and the fascicles of the branches are disposed around the stem in spirals, so that for every complete spiral, formed by five fascicles of branches, there are eight spirals formed by twenty leaves; four leaves being inserted between each pair of fascicles. The insertion of the fascicles, like that of the antheridia, is not in the axils of the leaves, but immediately at the side of the leaf, presenting some analogy to *Fontinalis*." The lid of the sporangium has been observed to be driven off with considerable force, so as to give a distinctly audible report. *Sphagna* are found both in the north and south hemispheres, but the species of the latter are all found in Europe.

III. Acrocarpi, *Bridel.*

Fruit terminating the main shoots.

523. There are no Cryptogams, ferns excepted, of which the arrangement is less satisfactory than that of Mosses. It is quite useless to propose divisions founded solely on the peristome, for their fallacy will be seen at every step we take. The habit is of far greater importance than the peristome. This, therefore, will be one great guide to affinities, though, as in other cases, its value must be weighed cautiously. The true key will probably be found hereafter in the structure of the young sporangium, which has at present been deeply studied

only in a limited number of genera. In the following tabular view I have adopted in great measure the arrangement of Bruch and Schimper, as it appears in Wilson's Bryologia, in conjunction with that contained in Montagne's excellent article in Orbigny's Dictionary, to which latter the student may be referred for many valuable remarks on the structure of Mosses in general. Mr. Wilson's work is entirely founded on close personal examination, and is indispensable to the student of Mosses, whether British or exotic. I have not included *Sphagnei* in the acrocarpous mosses, as is the case in Montagne's arrangement; for if the distinction of *Cladocarpi* is to be kept up, these cladocarpous mosses, which have no close affinity with any *Acrocarpi*, ought surely to be excluded. The distinction, of course, between Pleurocarpous and Cladocarpous is very nice; but whether it be right or wrong to retain the divisions, if there be any natural groups, they are to be found in the distinction of the great mass of Pleurocarpous from Acrocarpous mosses. It is not, however, to be denied that there are anomalies, as in *Cinclidotus* and *Fissidens;* but this may be said of every system. *Fissidens* is, in fact, to *Dicranum* what *Anœctangium* is to *Zygodon.* I cannot, however, regard *Sphagnei* and *Andrœacei* as distinct natural orders from other mosses.

ACROCARPI.

Phascei.—Sporangia indehiscent.

Weissiei.—Peristome 0 or 16-fid. Calyptra dimidiate. Tissue of leaves dense.

Dicranei.—Teeth split to the centre. Calyptra dimidiate.

Syrrhopodontei.—Teeth connivent or horizontal. Leaves sheathing.

Pottiacei.—Sporangia ovate. Peristome 0 or 16-fid. Tissue of leaves loose.

Trichostomei.—Teeth filiform, 32, distinct or in pairs.

Ripariacei.—Aquatic. Columella dilated above. Leaves nerved.

Hydropogonei.—Aquatic. Leaves nerveless.

Encalyptei.—Calyptra large, funnel-shaped, persistent.

Hedwigiacei.—Sporangia sub-globose. Peristome 0. Leaves nerveless.

Grimmiei.—Sporangium even, equal. Cells of leaves punctiform.

Ptychomitrei.—Calyptra furrowed. Teeth 16. Leaves punctate.

Octoblepharei.—Peristome 8-fid. Leaves white.

Orthotrichei.—Sporangium equal. Calyptra large, pilose; cells punctiform.

Zygodontei. — Sporangium pyriform. Calyptra small, smooth, dimidiate.

Tetraphidei.—Tip of columella quadrifid, attached to peristome.

Buxbaumiei.—Sporangium slipper-shaped. Outer peristome spurious.

Polytrichei.—Top of columella membranous or pilose. Rigid.

Leptostomei.—Peristome annuliform. Sporangium ascending.

Bryei.—Peristome double. Leaves large-celled.

Meesiei.—Sporangium irregular. Calyptra small.

Funariei.—Sporangium irregular. Calyptra inflated below.

Bartramiei.—Sporangium spherical. Leaves rigid, keeled, serrated.

Oreadei.—Sporangium spherical, small, on a curved stalk. Calyptra dimidiate.

Discelei.—Teeth 16, cloven at the base. Annual.

Splachnei.—Sporangium apophysate. Leaves larger-celled. Spores radiating from the columella.

Schistostegei.—Peristome 0. Leaves vertical, distichous, or pinnate. Spores radiating.

1. Phascei, *Mont.* (Phascacei, *Br. & Sc.*).

Annual or perennial. Sporangium sessile, or shortly pedunculate, with or without a columella, indehiscent, without any trace of peristome.

524. The numerous species belonging to this tribe, which contains the simplest of all mosses, are mostly of short duration, and occur on newly turned up soil. The leaves are rarely nerveless, and their borders composed of large cells. The sporangia vary somewhat in form, and are either absolutely sessile, as in *Archidium* (Fig. 102), or more or less shortly pedunculate, and their cavity either quite free, or traversed by a columella. In some of the species there are traces at first of a columella, but it is soon absorbed. The spores are larger than in most mosses; in *Archidium* they attain such a size

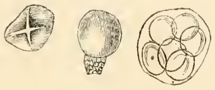

Fig. 102.

Young and old sporangium of *Archidium*, with spore from the angular side, magnified. Sometimes the spores are subglobose. From Hook. Herb.

Fig. 103.

Calyptra of *Voitia hyperborea*, magnified.

that the cavity contains only a very few, but even these appear to arise four together in the mother-cells, at least occasionally, if not always. In some of the species the confervoid shoots or protonema are persistent, as in *P. serratum*, *cohærens*, &c.; in other cases they soon vanish.

525. In *P. bryoides*, the peduncle is elongated beyond the usual limits of the tribe, but this character is still more striking in *Voitia*, which is, moreover, distinguished by the large persistent dimidiate calyptra (Fig. 103). Species occur in either hemisphere. Many European forms occur in the

United States; but, with one or two exceptions only, the species of the southern hemisphere are peculiar to it. Hong Kong produces one which is allied to *P. crispum.* The tribe, on the whole, belongs certainly to temperate regions; it is possible that the one or two European forms which occur at the Cape may have been introduced by cultivation. It still possesses some peculiar forms, and a distinct species of *Bruchia.*

2. WEISSIEI, *Mont.* (WEISSIACEI, *Br. & Sc.*).

Sporangium erect, equal. Peristome wanting, or consisting of 16 teeth, often united at the base. Tissue of leaves compact. Calyptra dimidiate.

526. A large number of genera are referred to this tribe, which contains numerous but often very obscure species. *Gymnostomum* has the aperture naked, and sometimes much contracted. In some of those species which are referred to *Hymenostomum*, the top of the sporangium remains attached to the apex of the columella, thus forming a closed sac at the period of maturity. *Weissia* differs from *Gymnostomum* merely in the presence of a peristome, consisting of sixteen teeth. These are sometimes bifid at the apex, and the genus is thus confluent with *Dicranum.* *Rhabdoweissia* has a striated sporangium ; in *Brachyodus* the teeth are very short and truncate; in *Seligeria* the sporangium is pyriform, with a large rostrate lid, and a cucullate calyptra, and from this *Anodus* differs only in the absence of a peristome. These are the principal British genera, but many others occur, of which I cannot speak particularly. They are found in both hemispheres, and some species, as *Weissia controversa, acuta,* &c., are common to both, though each has also its own species. *Eucladon* and *Lophiodon,* for example, are antarctic genera. The latter has the teeth approximated in pairs. *Eucamptodon perichætialis,* a Chili species, has already been noticed (Fig. 99, *e*) for its curious spores. A few species occur in hot climates, as, for example, *Gymnostomum lamprocarpum* in Dominica; *Weissia macrorhyncha* and *Miqueliana,* in Java. Montagne includes *Didymodon,* and other genera which have cleft teeth; but these come better under *Dicranei* or

Trichostomei; indeed, he has placed *Ceratodon* both in *Trichostomei* and *Weissiei.* Bruch and Schimper separate two distinct tribes from *Weissiei,* under the names of *Campylostelei* and *Seligerei,* the former of which includes the British genera *Campylostelium* and *Brachyodus,* and the latter *Seligeria* and *Anodus. Blindia* is also included in the latter, but Wilson places this with *Dicranei. Campylostelium* has a drooping geniculate peduncle, but *Brachyodus,* included with it, has an erect sporangium; the *Seligerei* are very minute, and their sporangia pyriform. The characters, however, at present seem very uncertain, and I prefer, therefore, following the arrangement of Montagne.

3. DICRANEI, *Mont.* (DICRANACEÆ, *Br. & Sc.*).

Sporangium even or striated; peristome single, consisting of sixteen teeth, split half-way down. Calyptra cuculliform, naked at the base or fringed.

527. This tribe contains a large mass of species, which are easily known by the teeth of the peristome being divided half-way down.* Some of the species are amongst the most common of mosses. *Stylostegium* and *Blindia,* which form the bases of two distinct tribes, appear amongst *Dicranei* in Wilson's arrangement, instead of amongst *Weissiei,* as in that of Montagne. The former has no peristome, and in the latter the teeth are not uniformly cloven, but sometimes perforated. *Campylopus* is separated under a distinct tribe, because of its fringed calyptra; but the multiplication of tribes, as of all divisions, beyond absolute necessity, is a great evil. It is, however, easily distinguished by this character, as also by the arcuate peduncle, and the lamelliferous ribs of the leaves (Fig. 99, *g*). Sandstone rocks, turbaries, shady banks, the trunks of trees, &c., are the favourite localities of these mosses, whose leaves are with few exceptions drawn out into long subulate points. Many of the species are minute; but others, again, are amongst the finer mosses. *Leucobryum* is remarkable for the pallid leaves, which have perforated walls (Fig. 99, *b*) like those

* This character is not, however, absolute or invariable. In *D. Tasmanicum, cerviculatum,* and others, they are frequently trifid.

of *Sphagnum*, with which genus it agrees in habitat. The chlorophyll cells are not, however, superficial, but imbedded in the centre of the leaf. *Cynodontium*, which has the habit of *Weissia cirrhata*, is almost intermediate between *Weissiei* and *Dicranei*. *Symblepharis* has the teeth approximated in pairs and connivent above. The leaves are extremely crisped and convolute. *Dicranodontium* is a *Campylopus* destitute of the fringe at the base of the calyptra. *Dicnemon* is perennial and has the habit of *Leucodon*. It differs principally from *Dicranum*, in the branched creeping habit. *Trematodon*,

Fig. 104.

Tooth of *Dicranum scoparium*, magnified. Moug., No. 120.

Fig. 105.

Teeth of *Trichostomum tortile*. magnified. Moug., No. 1012.

as the name implies, is known by its perforated teeth. The tribe includes many European species, some of which have a wide distribution. *Campylopus flexuosus*, for instance, occurs in New Zealand, India, Abyssinia, and South Africa, besides Europe. *Trematodon longicollis*, again, is found in New Zealand, South Africa, India, Java, Brazil, and Labrador. There are many noble species peculiar to the southern hemisphere, and some fine tropical forms. Some of these, however, as *Dicranum Siebierianum*, occur in more temperate districts. *Leucobryum* occurs in either hemisphere under the same species; but there are others which exclusively affect hot climates, as Guiana, Madras, Guadaloupe, &c. *Ceratodon purpureus* seems to be cosmopolitan.*

4. SYRRHOPODONTEI, *Mont.*

Sporangium straight, equal, destitute of a ring; peristome single; teeth connivent or horizontal, and thus closing the orifice. Base of leaves discoloured and amplexicaul or sheathing. Calyptra persistent, cuculliform, split in the middle.

528. This tribe consists of two or three tropical or subtropical genera, remarkable for the various characters assumed by the leaves, especially as regards the nerves and margin, and for the connivent teeth of the peristome; the base of the leaves, which is either sheathing or amplexicaul, is in *Syrrhopodon* and *Trachimitrium* remarkable for the discoloration of the tissues at the base, except the nerve and margin, from the absence of chlorophyll. The habit is somewhat like that of the larger *Weissiæ*, but on a grander scale, or some *Orthotricha*. The contrast between the sheathing scarious base and the thick patent elongated tip, in *Syrrhopodon*, is sometimes very striking. In *Calymperes*, the tip of the nerve, whether reaching to the summit or otherwise, is usually furnished with a tuft of gems (Fig. 100, *b*), which have been considered erroneously as constituting a distinct genus, *Bryomyces*. A species of *Calymperes* is marked in the Hook. Herb., as received from Tierra del Fuego, but the locality is probably wrong. The Pacific, East and West Indies, Guiana, &c., are the favourite localities of the genus. Several species of *Syrrhopodon* occur at the Cape, but most of the species are purely tropical. The same species occurs in India and Lima; but the species in general seem not to be widely diffused. *S. candidus* has very much the habit of *Octoblepharum*. *Trachymitrium* is a *Syrrhopodon* in everything except the rough calyptra, a character which does not, however, appear in Musci Ex., tab. 171, for the calyptra is represented there as perfectly smooth.

* I have notes of the following localities: Campbell Island, Falkland Island, New Zealand, Nilgherries, Chili, Quito, Abyssinia, Arctic regions, Tristan d'Acunha, Victoria, Nova Scotia, and India Orientalis.

5. Pottiacei, *Br. & Sc., Mont.*

Sporangia pedunculate, straight, oval; peristome none, or 16-fid; calyptra mitriform; leaves green, composed of wide large cells. Annual or biennial.

529. These mosses are at once distinguished from *Phascum* by their constantly pedunculate and dehiscent sporangia. They are common either on newly moved soil, like *Phascei*, or on the mudcaps of walls, or situations corresponding with them in character. The fruit is either altogether destitute of a peristome, as *Pottia*, or, as in *Anacalypta*, there are sixteen teeth united at the base by a membrane. It is, however, not

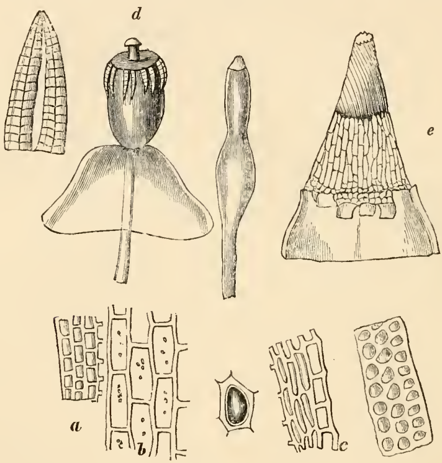

Fig. 106.

a. Portion of edge of leaf of *Gymnostomum curvirostrum*, magnified. Moug., No. 905.

b. Ditto of *Pottia truncata*, var. major. Moug., No. 809.

c. Ditto of *Orthotrichum Bruchii*, from the base and towards the tip, with a single cell of the latter. Moug., No. 826.

d. *Splachnum luteum*, young and old sporangium with a pair of teeth. From Hookerian Herbarium.

e. *Buxbaumia aphylla*. After Schimper.

certain whether the same species may not sometimes exhibit the characters of the two genera. But however this may be, the peristome is very variable in the same species, insomuch that in different conditions it might be referred to several genera. Mr. Wilson, for instance, mentions a form of *Anacalypta lanceolata,* found at Bristol by Mr. Thwaites, with a red peristome, the teeth of which were distinct almost to the base, unusually long, with sometimes two rows of perforations. The gymnostomous *Weissiei* are distinguished by the compact reticulation of the leaves. The species are all monœcious, and consequently abound in fruit. The species belong mostly to the northern hemisphere, and to the colder parts; but *Pottia Heimii* occurs at the Cape, and is widely distributed in higher latitudes; and *P. flavipes* in Chili; while *P. Leprieurii* is found in Cayenne. Not a single species occurs in New Zealand.

6. TRICHOSTOMEI, *Br. & Sc., Mont.*

Peristome consisting of thirty-two filiform teeth, distinct or united at the base, frequently approximating in pairs, and sometimes spirally twisted.

530. We have here, again, a large and very important mass of species comprised under numerous genera, and exhibiting various modifications of the peristome, which is, however, always finely divided, and in one section curiously twisted, the tissue of the operculum itself following the same course. All agree more or less in the tufted habit, except where the individual plants are scattered, as in some of the more obscure species. *Tortula ruralis* is one of the most conspicuous of our mosses, from the large patches which it forms on slated or thatched roofs. *Trichostomum glaucescens* is remarkable for the glaucous hue which occurs again in *Bartramia. Desmatodon nervosus* is sometimes destitute of peristome, while at other times the slender tips of the teeth are twisted. It occurs in either hemisphere. The tribe is eminently European and American, but the tropics are not without species of either section, and many occur in the southern hemisphere, which are mostly distinct. *Ceratodon* oscillates between this tribe and *Dicranei,* to the latter of which it approaches nearest in the foliage, to the former in the peristome. *Didymodon*

glacialis is one of the three mosses gathered in Cockburn Island, lat. 64° 57′ south; the others being *Tortula lævipila* and *Tortula gracilis*, so that species of this tribe seem to have greater powers of endurance than any others.

7. Ripariacei, *Br. & Sc.*, *Mont.*

Aquatic; sporangium immersed in the leaves, or more or less exserted; lid conico-rostrate, spiral; peristome consisting of thirty-two teeth, connected together by anastomosing processes, or of an irregular fissured, sometimes rudimentary, membrane; top of the columella dilated and connected with the peristome; leaves dark green.

531. The three species of which *Cinclidotus* is composed, and which is the sole European tenant of this tribe, differ from each other in the acrocarpous and cladocarpous growth of the fruit. They agree more or less with *Fontinalis* in habit, and are allied to *Tortula*, from which they differ principally in the anastomosing processes which connect the lower portion of the teeth. These are not always definite in number. The teeth, in fact, are quite rudimentary in *C. aquaticus*. Like most aquatic plants, they are capable at times of growing in the free air; and the terrestrial variety, *C. riparius*, which is at present the only one which has been found in England, is quite a *Tortula* in habit. *Wardia* and *Scouleria*, which are also aquatic, seem near allies. In *Scouleria*, which grows in streams amongst the Rocky mountains, there is a process at the top of the columella with which the thirty-two laciniated teeth are probably at first in connection. In *Wardia*, which is found at the Cape, there is the same dilated columella, the peristome consisting of an irregularly fissured membrane. There can be little doubt that these plants are intimately united; and if so, the character of the tribe will depend not on the cancellation, but on the dilated columella. No species appears in the Antarctic or New Zealand Floras, though *Wardia* may be expected in the latter.

8. Hydropogonei, *Mont.*

Aquatic; sporangium equal, concealed amongst the leaves; peristome none or simple; operculum plane or acuminate; leaves nerveless.

532. The principal distinguishing feature of this small tribe, which consists but of two genera, *Hydropogon*, founded on the old *Grimmia fontinaloides*, and *Cryptangium*, seems to consist in the nerveless leaves. In most of the aquatic mosses there is a tendency in the sporangia to become immersed in the perichætial leaves, but in none is this character so strong as in *Hydropogon*. *H. fontinaloides* appears to be common on the Orinoco, near San Fernando, as it is called Barba de palo by the natives. The main stems are quite bare of leaves; the branchlets, however, are beset with densely imbricated, nerveless, oblong, serrated leaves, which gradually pass into more pointed perichætial leaves, concealing the minute, oblong, erect, nearly sessile, sporangium. The peristome consists of sixteen obtuse teeth more or less jagged. In the other genus, from Cayenne, the operculum is acuminate instead of umbonate, and the peristome is altogether wanting.

9. Encalyptei, *Br. & Sc.*, *Mont.*

Sporangium straight, cylindrical, even or striate, covered by the large funnel-shaped persistent calyptra; peristome none, single or double.

533. Though the characters of the peristome vary so greatly in the species of which this tribe is formed, they are so connected by general habit, and by the large cylindrico-campanulate persistent calyptra, that there can be no doubt about their affinity. Their habit is that of some of the larger species of *Tortula*, and they grow on the tops of walls, or on stones and rocks, especially those which are calcareous, of which they constitute a chief ornament when abundant. In *E. commutata* the peristome is wholly absent; in *E. vulgaris* it is very fugacious; in *E. ciliata* it is persistent, consisting of sixteen teeth; in *E. streptocarpa* it is double, the outer consisting of sixteen teeth, the inner of as many processes, alternating with the outer. The species are almost exclusively confined to Europe or North America, but there are traces of the genus in Chiloe, Peru, and Kumaon.

10. Hedwigiacei, *Br. & Sc.*, *Mont.*

Sporangium globose or oblong, more or less immersed;

peristome none; calyptra conical, smooth, or hairy; leaves nerveless.

534. The mosses of which this tribe is composed are distinguished by their nerveless leaves, the absence of the peristome, and the lax, not compact, patches which are formed by the shoots. In the European forms the stem is often very short, but this is by no means the case uniformly. They occur in alpine countries, but are not confined to cold regions. Species are found in Brazil, Kumaon, St. Vincent's, and other tropical stations; and the southern hemisphere has one or two extending from the Cape to higher latitudes. *Hedwigia Humboldtii*, for instance, occurs at the Cape and at Hermite Island; and the same species is abundant in Lord Auckland's and Campbell Island. This is perhaps the finest of the tribe, and was originally found on Quindiu, in New Grenada, by Humboldt and Bonpland, so that the species has an immense geographical range. This tribe might probably be united with *Hydropogoneæ*. The characters, at least, are very similar. They differ principally in their habitat.

11. Grimmiei, *Br. & Sc.*, *Mont.*

Sporangium equal, often sessile; peristome single; calyptra mitriform; leaves of a dark green, always terminated by a white hair; cells punctiform.

535. The minute hexagono-punctiform cells of the upper part of the leaves and the white projecting nerves distinguish these mosses, which either form dense pulvinate tufts or widespread masses. *Racomitrium lanuginosum*, for instance, forms beds many yards in diameter on dry mountain sides, than which nothing can be softer or more luxurious. *Schistidium* differs principally from *Grimmia* in the immersed sporangia, and the columella adherent to the lid. The peristome is extremely variable; the teeth are often split as in *Dicranum*, and in one species they are altogether absent. *Racomitrium* differs from *Grimmia* in the hypnoid habit, a distinction confirmed by the subulate papillose beak of the calyptra. It is connected with *Grimmia* by *Dryptodon*, which has dichotomous branches and simple fastigiate innovations; while in *Racomitrium* the branches are irregular, and the innovations

are not fastigiate. The characters are, however, very inconstant even in the same species. *Grimmia apocarpa** is abundant in both hemispheres, and appears both in Kumaon and Mendoza; other species affect equally the temperate realms of either hemisphere; but a few only are tropical or local.

12. PTYCHOMITRIEI, *Br. & Sc.*

Sporangium destitute of a tapering base; calyptra smooth, furrowed, its apex subulate; primary teeth not more than sixteen; cells of leaves punctiform, not papillate.

536. This small tribe, included by Montagne in *Orthotrichei*, differs from *Grimmiei* in the furrowed calyptra, and from *Orthotrichei* in the texture of the leaves, smooth subulato-calyptra, and in the sporangium not tapering at the base. The spore-sac, moreover, is connected closely with the mitriform walls of the sporangium. It consists of three genera—*Coscinodon*, *Glyphomitrium*, and *Ptychomitrium*. The former is remarkable for its cribrose teeth. *Ptychomitrium* differs essentially from *Racomitrium* in its plicate calyptra, and from *Glyphomitrium* in its sixteen deeply bifid teeth, whereas those of *Glyphomitrium* are lanceolate and disposed in pairs. They are confined, I believe, to the northern hemisphere.

13. OCTOBLEPHAREI, *Mont.*

Sporangium regular; peristome consisting of eight undivided teeth; calyptra conical, entire; leaves white, with perforated cell walls, and imbedded chlorophyll cells.

537. This tribe is remarkable for possessing (Fig. 99, *a*) the colour and perforated cell-walls of *Sphagnum*, without, however, the spiral thread. Moreover, those walls alone are perforated which are in contact with others, and not those which are external. The resemblance, however, to *Sphagnum* is more apparent than real, for the whole structure of the fruit is different. *O. albidum* is a common inhabitant of the trunks of trees in hot countries: the coast of Africa, central America, Brazil, Oahu, Java, Mauritius, and the East Indies, are

* I have marked in my notes as localities for this species, United States, Greenland, Kumaon, Hermite and Falkland Islands, Mendoza, New Zealand, Spain, Arct. Regions, Hymettus, and Europe in general.

amongst the localities from which I have seen specimens. It has not been found in New Zealand. The habit is similar to that of some *Orthotricha*.

14. ORTHOTRICHEI, *Br. & Sc., Mont.*

Sporangium equal, mostly striated; peristome variable; calyptra mitriform, generally covered with erect hairs; leaves keeled, margins often involute; cells punctiform, papillate.

538. We have here, again, a large mass of species, of which, though many belong to the northern hemisphere, there are a great many tropical and southern species. The calyptra is, for the most part, covered with straight hairs, and more or less divided at the base; but this character is not absolute, and the peristome is so variable as to afford no characters on which strict dependence can be laid. *Macromitrium* has a narrow subulate calyptra, which is not dilated previous to the development of the sporangium; it has no apophysis, and the operculum is rostrate. The genus abounds in species, many of which belong to the southern seas, while others occur in Brazil, India, Abyssinia, and other hot countries. *Schlotheimia* has four appendages at the base of the calyptra, and with the exception of *S. Brownii*, and one Cape species, all belong to the tropics. *Orthotrichum* proper, on the contrary, may be considered as belonging pre-eminently to the northern hemisphere. *Glyphomitrium* is allied to *Grimmia*, but agrees with the present tribe in its paired teeth, and large plicate calyptra, with which character *Ptychomitrium*, again, accords. *Leucophanes* agrees in appearance with *Leucobryum*, and is confined to the tropics.

15. ZYGODONTEI, *Br. & Sc., Mont.*

Sporangium striated, pyriform; peristome 0, single or double; calyptra dimidiate, smooth; habit that of *Gymnostomum.*

539. The species of this tribe have the habit of *Gymnostomum*, but they are related to *Orthotrichei*, differing mainly in their smooth cuculliform calyptra. The operculum, too, is longer and oblique; the leaves, moreover, are never revolute. Sometimes, as in *Z. viridissimus*, the plants are diœcious, and the fruit, in consequence, of rare occurrence. The leaves

are punctate. In *Codonoblepharum* the peristome is double, and the inner consists of sixteen cilia arising from a basilar membrane, and whose connivent tips form a sort of bell, from whence the name. The species are in the first place inhabitants of Europe and North America; *Zygodon conoideus* appears in Tasmania; while *Z. viridissimus* is found in the Neelgherries. The New Zealand species are southern species, with the exception of *Z. obtusifolius*, an Indian form; while *Z. intermedius* is found in Chili.

16. Tetraphidei, *Br. & Sc., Mont.*

Sporangium erect; calyptra mitriform, plicate; peristome united with the top of the columella, which is divided into four pyramidal teeth; teeth irregularly reticulated.

540. The few species of which this small tribe is composed are scarcely exceeded in interest by any mosses, for the peristome, instead of consisting of a regular series of cells as in other species, is merely a sort of membrane stretched over the top of that portion of the columella which separates from that which remains within the operculum, and with it splits into four irregular teeth. It does not, indeed, seem quite certain whether the four teeth are perfectly homologous with the teeth of other mosses; authorities differ in this respect. At any rate, the arrangement of the cells is not symmetrical. *Tetraphis pellucida* forms dense green patches at the roots of trees or on peaty banks, while *Tetrodontium Brownianum* is remarkable for its dark colour, and the absence of anything in addition to the perichætial leaves, except long strap-shaped processes, which seem as much entitled to the name of branches as of leaves. *Tetraphis pellucida* occurs in N. America, but I am not aware that any species of the tribe is found in the southern hemisphere.

17. Buxbaumiei, *Br. & Sc., Mont.*

Sporangium slipper-shaped, oblique, pedunculate, or sessile; calyptra short, conical.

541. This small but highly curious tribe consists of two genera only. The first, *Buxbaumia*, has a large apophysate sporangium, flat above and convex below, seated obliquely on a rough stalk with a small calyptra, just covering the lid: the

peristome is apparently double (Fig. 106, *e.*), but Wilson shows that the outer peristome, which consists, like the peristome of *Tetraphis*, of irregular cells, is an excrescence from the more external layers of the tissue of the sporangial membrane, of which, he says, we find analogous though less evident examples in *Polytrichum* and *Orthotrichum;* the leaves are few in number, nerveless, fringed, and broadly reticulate. In *Diphyscium*, on the contrary, there is a tuft of nerved spreading leaves; the sporangium is almost sessile, the outer peristome almost rudimentary, and the inner consisting of a plicate conical membrane, thickened at the sixteen salient angles. The nearest affinity is with *Polytrichum*, but the habit of *Diphyscium* is that of *Phascum*, and its duration scarcely more than annual. There is a second species of *Buxbaumia*, which has not yet been found in Great Britain; another appears in Java and Australia. A species of *Diphyscium* is found at Myrong.

18. POLYTRICHEI, *Br. & Sc.*, *Mont.*

Mouth of sporangium mostly closed by a flat membrane; calyptra rough with dependent hairs, rarely naked.

542. This is an important tribe of acrocarpous mosses, containing some of the very finest species, which are remarkable not only for beauty, but for structure. The spore-sac is sometimes separated from the columella as well as from the sporangial wall, and waved, so that the sporangium when cut across looks like a real capsule. The sporangium is often quadrate, furnished with an apophysis below; the calyptra is rough, with silky hairs, which are a sort of paraphyses, but distinct from the true attendants on the archegonia; they are developed after impregnation, and arise partly from the vaginula, partly from the walls of the archegonium. The peristome consists of 32—64 teeth, united above to the membranous drum-like top of the columella. *Polytrichum* is divided into several subgenera, which it is not necessary to distinguish here. *Dawsonia* differs from *Polytrichum*, in having an oblique sporangium like *Buxbaumia*, and in the numerous cilia of the peristome, which are either free or partly connected with the top of the columella. *Lyellia* has a similarly shaped

sporangium, but the whole aperture is closed by a diaphragm, from which an orbicular central portion at length separates with the columella, which contracts within the sporangium. *Lyellia* is a Nepalese, *Dawsonia* an Australian genus, extending to New Zealand. In *D. superba* no part of the peristome adheres to the columella.* *Polytrichum* is an enormous genus, and is found everywhere. *P. dendroides* is a foot or more high, and has a wide range in the southern hemisphere; this, however, is equalled if not exceeded in size by *P. giganteum; P. tortile* extends from Surinam to New Zealand, while *P. juniperinum* is almost cosmopolitan; *P. aloides* occurs in several places in India; *P. ciliatum,* as the name implies, has the leaves beautifully ciliated; *P. giganteum* is one of the largest of mosses. It has been stated that the stem of some of the large *Polytricha* shows concentric rings of growth, but I have been unable to detect such a structure. The leaves of *Polytricha,* except in a few instances, are very rigid, and their nerve often exhibits on its surface numerous lamelliform folds.

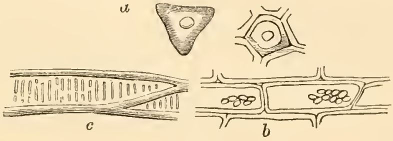

Fig. 107.

Polytrichum dendroides.

a. Horizontal section, slightly magnified.

b. Vertical section of light coloured cells containing starch grains, highly magnified.

c. Ditto of dark external cells showing scalariform markings on the walls, too strongly expressed in the figure.

d. Horizontal section of one of the same cells.

19. Leptostomei, *Mont.*

Sporangium ascending; mouth contracted; peristome membranaceous, annuliform, erect; leaves oblong, terminated by a hair.

* The teeth of *Polytrichum* consist of many threads soldered together. *Dawsonia* exhibits these threads in a state of solution.

543. The mosses which constitute this curious tribe have somewhat the habit of *Bryum*, from which they are known at once by their single imperfect peristome. This single peristome, however, it has been observed by Schwægrichen, answers to the inner peristome of *Brachymenium*, the outer peristome being entirely suppressed, or reduced to a mere rudimentary border. The peristome of *Leptostomum*, though membranous

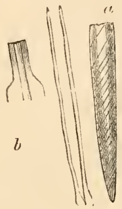

Fig. 108.

Dawsonia superba.

a. Spiral structure of lining of external cells of stem.
b. Teeth of peristome.

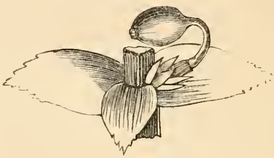

Fig. 109.

Cyathophorum pennatum.

Portion of the stem magnified, to show the origin of the pleurocarpous fruit.

below, has the border frequently divided, more or less regularly, into sixteen often bifid teeth. *Leptostomum* is essentially a genus of the southern hemisphere, New Zealand and Tasmania being its head quarters. *L. splachnoides* is found in Chili, and one ascends as high as the Organ Mountains of Brazil.

20. BRYEI, *Br. & Sc.*, *Mont.*

Sporangium erect or cernuous, smooth or striate, cylindrical, pyriform, or urceolate ; peristome double ; calyptra dimidiate ; leaves mostly margined and toothed, composed of rhomboidal cells.

544. This is a very important tribe, distinguished by the loose reticulation of the margined leaves, the regular sporangia, and the highly developed double peristome. The sporangia are for the most part cernuous, but this is by no means a

universal character. The species vary greatly in size, but a large number even of our European representatives are amongst the finest of mosses, whether as regards the size of the leaves or the beauty of the peristome. *Timmia* is remarkable for its having the habit of *Polytrichum*, in consequence of the sheathing base of the leaves, and their spreading tips. *Aulacomnion androgynum* has abundant large tufts of gems upon distinct peduncles. In *Aulacomnion palustre*, on the contrary, these organs are far more rare; in both, the sporangium is striated. The genus *Bryum*, without any of its dismemberments, contains thirty-three British species, many of which, with their large abundant sporangia, are extremely ornamental; but the crown of all are the species of *Mnium* and *Cinclidium*, with their large ligulate or orbicular leaves, and abundant often aggregate sporangia. Few Cryptogams are finer than well-grown fruited specimens of *Mnium punctatum* and *undulatum*. The latter is one of the commonest ornaments of our woods, but it is rare to find it in fruit. All these are especially European forms, but *Brachymenium* is as essentially tropical. India, Java, and Mexico are its favourite abodes, but there are one or two species at the Cape, and one doubtful species is found in the Falklands. *Bryum*, however, and its more immediately allied genera, are amply represented in the south; of the genus *Bryum* alone, New Zealand possesses nineteen species, with two of *Mnium*, and one of *Orthodontium*. *Mnium*, moreover, has a beautiful representative at the Cape, in *M. umbraculum*.

21. MEESIEI, *Br. & Sc.*, *Mont.*

Sporangium irregularly obovate or obconic, sub-erect, tapering below into the very long stem, gibbous at the back; peristome double, not hygroscopic.

545. The species of this group are all inhabitants of marshes, remarkable for their very long peduncles and sporangia, approaching in character those of *Funaria*. *Paludella squarrosa*, which like many diœcious mosses is rare in fruit, is remarkable for its squarrose foliage; *Meesia uliginosa* is our only certain *Meesia*. *Amblyodon dealbatus*, as the name implies, has short blunt outer teeth, above which the

inner peristome arises, deeply divided into sixteen narrow keeled processes; *Diplocomium longisetum* is a very doubtful native; all may be considered as European forms.

22. FUNARIEI, *Br. & Sc., Mont.*

Sporangium pyriform, straight or oblique, smooth or striate; peristome variable; calyptra inflated below, subulate above, vesicular, split at the base. Sub-biennial, monœcious; reticulation loose.

546. This tribe consists of three genera—*Physcomitrium*, *Entosthodon*, and *Funaria*, all agreeing in the vesicular inflated calyptra, and annual or sub-biennial habit, but in *Physcomitrium* there is no peristome; in *Entosthodon* the peristome is single, and in *Funaria* double. Valentine has carefully analysed the young fruit of *Funaria hygrometrica*, Linn. Tr., vol. 17, and has shown that the base of the young fruitstalk burrows down into the receptacle.* *Physcomitrium* is a European or N. American genus, with representatives in India, South America, and New Zealand, where *P. pyriforme* appears under a dwarfed form with the Indian *P. Perrottetii*. *P. pusillum* has the calyptra but slightly inflated. *Entosthodon* has but one European species, New Zealand has one, and Peru three species, while two appear in Algiers. The species of *Funaria* are widely spread. *F. hygrometrica* is cosmopolite, and the other species have mostly a wide distribution, though New Zealand produces two distinct species.

23. BARTRAMIEI, *Br. & Sc., Mont.*

Sporangium spherical, mostly striated; peristome variable, but resembling that of *Bryei*; leaves rigid, lanceolate, keeled, denticulate. Perennial.

547. These mosses have a peculiar habit, which, in conjunction with their spherical and mostly striated fruit, distinguishes them at once from *Bryei*, with which they are connected by

* An analysis will also be found in Schimper's Recherches sur les Mousses. Compare also remarks on *Funaria*, in Wilson's Introduction to Bryologia Britannica. One peculiarity of structure consists in the columella not arising at once from the axis of the peduncle, but being merely connected with it by a few loose threads. A different structure is figured by Payer.

Oreadei, mosses of a very different aspect. They are found occasionally in flat countries, but they are far more frequent amongst the mountains, where they are the ornament of many a damp spot. *Bartramidula*, whose pale pink capsules are very ornamental, is remarkable for the spore-sac being united with the top of the columella, as in *Hymenostomum*, and a total absence of peristome. In *Bartramia* it is likewise occasionally absent, and when present may be either single or double. *Conostomum*, which is the only remaining British genus, has sixteen teeth united above, and forming a cone. *C. boreale* is a northern moss, and has never been found in Wales. There is, however, a southern hemisphere species, *C. australe*, which has a longer lid, and less serrated, broad-nerved, bristle-pointed leaves. There is also another minute New Zealand species, and one is found at Quito. *Cryptopodium*, a New Zealand and Australian genus, is distinguished by the immersed sporangium and double peristome. The long operculum is shaped as in *Bryum*, and not as in *Bartramia;* the sporangium, moreover, is oval rather than spherical. *Bartramidula* has been found only in Ireland; *Bartramia* abounds in species, and is found over the whole world. *B. pulverulenta*, a Casapi species, has glaucous leaves like *Trichostomum glaucescens.* In either case the glaucous matter is entirely extraneous and flocculent, without any distinct structure; but whether it consists of matter cast off like epithelium from the leaves or not, I have been unable to determine. *B. rigida* is found in Madeira, and great part of Central or South America, as well as in Europe. *B. marchica* and *Halleriana* appear in New Zealand, but there are besides several strictly southern representatives.

24. OREADEI, *Br. & Sc.*, *Mont.*

Sporangium small, rounded, borne on a curved peduncle. peristome single; calyptra dimidiate.

548. The best known example of this tribe to British botanists is the old *Weissia nigrita*, now referred by Bridel to *Catoscopium*, remarkable for its small, globose, dark, shining sporangia, suddenly bent and tapering into the long peduncle. The peristome consists of sixteen irregular lanceolate or trun-

cate teeth, marked with a central line. The genus *Oreas*, which has not yet been found in Great Britain, is founded on *Weissia Martiana* (Hook. Musc. Ex., t. 104). The sporangium is deeply sulcate, and red with greenish furrows; the peristome is of a deep red, and consists of sixteen transversely striate teeth. At present these plants appear not to have occurred out of the northern hemisphere.

25. DISCLELIEI, *Br. & Sc., Mont.*

Sporangium sub-globose, cernuous; ring large, sub-persistent; calyptra subulate, dimidiate; teeth sixteen, cloven at the base. Annual, almost stemless.

549. This tribe consists of but a single European genus, combining the habit of *Phascum*, with the sub-globose sporangium of *Catoscopium*, and the teeth of *Trematodon*. "During the autumn," says Mr. Wilson, "the clayey declivities where *D. nudum* grows, are covered with the green velvety thallus, which withers or becomes discoloured after the formation of the fruit, and very frequently falls down by the action of the winter frosts, along with the sub-stratum, which thus presents annually a new surface favourable for the vegetation of this singular moss, which much resembles a *Phascum* in the mode of its vegetation." See also Bot. Zeit., 1843, p. 505, t. 2.

26. SPLACHNEI, *Br. & Sc., Mont.*

Sporangium straight, with a swelling at the base, often of greater diameter than itself; leaves diaphanous, large-celled. Plants generally springing from decayed wood or dung of animals.

550. This tribe contains many of the most singular and beautiful species in the whole order of mosses. The enormous size which the swelling at the base of the sporangium of some attains (Fig. 106, *d*), the variety of colouring, the singularity and elegance of the forms, and in some cases the unusual dimensions, make the species objects of great interest. The common *S. ampullaceum*, when growing in abundance on the shallow peaty banks of some mountain stream, where the cattle often resort for watering, is exceeded in beauty by scarcely any Cryptogam. In *Splachnum vascalosum* the

dark purple apophysis arrives at a large size, but this is nothing when compared with the same organ in *Splachnum luteum* (Fig. 106, *d*) and *rubrum*, which are the pride of hyperborean Europe and America. The apophysis does not always arrive at its full size before the maturity of the sporangium. In *S. luteum*, for instance, it is very small at first, and acquires its extraordinary dimensions only at a late period. Species are abundant in the southern hemisphere, as well as the northern; but the same species rarely occur in both divisions of the world. The habits, too, are different. While those of the north grow only on dung, those in the south grow on the trunks of fallen trees. *S. angustatum* has, however, been said to occur on cow-dung, on the sandy sea-shore at Port Philip. The apophysis in the southern species is seldom very highly developed, but in *S. Gunnii*, a Tasmanian species, it is very peculiar, resembling a little Turk's-cap gourd. *Splachnum* has been divided into several genera, on more or less justifiable grounds. Of these, *Tetraplodon*, *Tayloria*, and *Dissodon* occur in Great Britain. The length of the teeth in *Tayloria splachnoides*, and the curious manner in which they are curled inward when wet, and diffused when dry, are very striking. One of the most remarkable genera, however, is *Œdipodium*, which differs from the rest, not only in its confluent apophysis, but in the absence of a peristome; the columella, however, being dilated at the apex. It grows, moreover, in the crevices of alpine rocks, and appears to differ from other *Splachna* in not having the spores radiating from the columella. Gems are found in the axiles of the upper leaves of most of the species.

27. SCHISTOSTEGEI, *Br. & Sc., Mont.*

Sporangia sub-globose; peristome none; calyptra dimidiate, fugacious; spore-sac adnate with the walls; leaves distichous, free at the base, or confluent; protonema perennial.

551. This tribe consists of but a single species, one of the most elegant of mosses. It loves the shade of caverns, which are sometimes lighted by a golden-green gleam from the refraction of the confervoid shoots. These are perennial, and produce year after year a new crop. The leaves show

various intermediate stages between a vertical and horizontal insertion, and are sometimes perfectly free; while at others they are united, and have in consequence a Jungermannioid aspect. The name was originally given on account of a supposed tendency in the lid to become fissured; but it is as entire as in other mosses. The lower half of the vaginula is leafy, as in most Pleurocarpous mosses. The spores in young sporangia radiate from the columella, as they do in *Splachna*. It seems to be confined to the northern hemisphere, but is far from being generally diffused anywhere.

IV. Cladocarpi, *Mont.*

Sporangia seated at the tips of very short lateral branches.

552. Having separated the *Sphagnei* from the Acrocarpous mosses, on account of their peculiar characters and intimate relation with the *Schistocarpi*, we have, after the few exceptional cases afforded by such genera as *Cinclidotus*, a group connecting plainly the Acrocarpous with the Pleurocarpous mosses. They are, indeed, few in number; but as they cannot conveniently be associated with either, it is well to place them in a distinct division.

1. Mielichoferiei, *Br. & Sc.*, *Mont.*

Vivacious, biaxile, cladocarpous; sporangium straight; peristome simple or double, with or without an apophysis.

553. These mosses are closely related to *Bryei*, but differ greatly in their double axis of growth. The vaginula is distinctly formed as in the Acrocarpous mosses, but the fertile branch is truly lateral, putting forth rootlets at its base, and closely resembling the perichætium of the *Pleurocarpi*. In one or two instances, however, it is difficult to say whether the portion which bears the sporangium is the main axis, with an elongated barren branch growing beneath it, or whether the latter is in reality primary. In *Mielichoferia* the sporangium is pyriform, or clavate with a large annulus, and simple peristome of sixteen teeth confluent below, and resembling that of *Anacalypta*. *Pleurogonium* has eight pairs of broad short teeth. *Diplostichum* has sixteen teeth united at the base, as in *Mielichoferia*, but the leaves are distichous. The

species are but few, and belong partly to the northern hemisphere, partly to South America, below the line. *Mielichoferia* has representatives also at the Cape, in Abyssinia, and in Kumaon. *Schizhymenium,* Harv., a Cape genus, has a double peristome, the inner of which is beautifully cancellated, and the outer very deciduous.

V. Pleurocarpi, *Bridel.*

Sporangia lateral, growing from purely perichætial branches.

554. If there was some room for doubt about the significance of the fruit-bearing branches in the *Cladocarpi,* there is none here. They are reduced to so small a size that they bear little or no resemblance to the main branches from which they are developed, and the leaves with which they are beset are purely perichætial. In one or two cases, as in *Fissidens* and *Anœctangium,* the connection with Acrocarpous mosses is so complete, that there is little to separate them, save the mode of growth; but in the generality of cases there is scarcely any immediate connection with the earlier tribes.

PLEUROCARPI.

- *Anœctangiei.*—Sporangium ovate or spherical, gymnostomous.
- *Drepanophyllei.*—Leaves equitant. Peristome single.
- *Fabroniei.*—Leaves imbricated. Teeth 16, arranged in pairs.
- *Fontinalei.*—Aquatic. Sporangium subsessile. Peristome double.
- *Cryptotheciei.*—Leaves imbricated. Calyptra mitriform. Peristome double. Habit diffuse.
- *Hookeriei.*—Stems flattened. Leaves imbricated. Calyptra mitriform.
- *Neckerei.*—Stems mostly compressed and pinnate. Peduncle usually short or wanting. Calyptra dimidiate.
- *Hypnei.*—Leaves mostly imbricated. Peduncle long. Peristome double. Calyptra dimidiate.
- *Leucodontiei.*—Leaves imbricated. Sporangia erect. Calyptra dimidiate.
- *Rhizogoniei.*—Sterile stems frondose; fertile perichætial. Calyptra dimidiate.
- *Phyllogoniei.*—Leaves distichous, folded. Peristome single. Calyptra dimidiate.
- *Hypopterygiei.*—Leaves trifarious, the third row smaller than the others (amphigastra).
- *Racopliacei.*—Leaves dimorphous. Calyptra pilose below.

1. Anœctangiei, *Br. & Sc.*, *Mont.*

Sporangium ovate or spherical, with a small persistent annulus, but entirely free from peristome ; vaginula perfect ; calyptra cuculliform, subulate ; leaves imbricate ; areolæ small.

555. Except in the mode of origination of the sporangia from true perichætial branches rooting at the base, and ultimately deciduous, there is no character to separate this tribe from *Gymnostomum.* The species differ, however, from most other Pleurocarpous mosses, in the perfect formation of the vaginula. There is but a single genus which consists of a few species only. Such species as *A. imberbe* and *ciliatum* now appear under *Hedwigidium* and *Hedwigia.* The species belong to Europe, Mexico, and the upper part of South America. There is no trace of them in the southern hemisphere. *A. compactum*, which is the only certain British species, has somewhat of the habit of *Gymnostomum curvirostrum.*

2. Drepanophyllei, *Mont.*

Fissidenteæ, *Br. & Sc.*

Stems flat ; leaves distichous, equitant ; sporangium pedunculate ; teeth 16, bifid ; calyptra cuculliform, more rarely conical.

556. This tribe is distinguished from almost all other mosses by the peculiar character of the leaves, which are, in fact, equitant. The two limbs are folded together, and the nerve is expanded into a lamina, which, however, frequently vanishes in the lower leaves. The peristome is that of *Dicranum*, from which *Drepanophyllei* are widely separated by habit. The fruit is not always strictly pleurocarpous. As in the last tribe there is a distinct vaginula. Few species are more interesting when closely examined, and the larger forms are very striking objects. Many occur in New Zealand, and they are often the same with European species ; others are scattered about in Java, India, Cayenne, and other localities. The species of *Fissidens* grow mostly on shady banks, or near watercourses. *Conomitrium*, which is the same genus with *Octodiceras*, occurs actually in watercourses, and has a float-

ing habit. It is distinguished by the teeth not having a central line, and being generally truncate and irregular. The calyptra is conical, with, usually, an entire base. Most of the species occur in the southern hemisphere, but one is found in France, and is amongst the most interesting of European mosses. The greatest ornament of the tribe, however, is *Drepanophyllum*, which appears to abound in Cayenne, from whence Leprieur has distributed many fine-fruited specimens. It is found also in Bourbon. It differs greatly from the others in the imperfection of the peristome. The shoots often bear terminal tufts of filiform gemmæ. These gems and the female organs are sometimes close together. The plant is, however, diœcious. In *Conomitrium* the male and female organs are sometimes approximated.

3. FABRONIEI, *Mont.*

Leaves imbricated, entire or ciliated, nerveless or furnished with an excurrent nerve; sporangium lateral, urceolate; peristome 0, or consisting of sixteen teeth, approximated in pairs.

557. The species of which this small tribe is composed, are small tufted plants with cylindrical imbricated stems. There are but two genera. Of these, *Aulacopilum* has a large sulcate calyptra split on one side, and covering the sporangium, which has no peristome. The leaves are glaucous, nerveless, and secund, with granular areolæ. *Fabronia* has a cuculliform calyptra; a peristome consisting of sixteen teeth, approximated in pairs, so as to look like eight; and leaves, for the most part, ciliato-dentate, with an excurrent nerve, and loosely reticulated. *Aulacopilum glaucum* grows with *Fabronia* in New Zealand. Other species of *Fabronia* occur in Quito, Brazil, India, Abyssinia, Australia, and South Africa; and one species occurs in Italy and the Cevennes. The reticulation of the leaves in *Aulacopilum* is very different from that in most *Fabroniæ*, but the habit is the same. The texture, however, varies in the latter genus.

4. FONTINALEI, *Br. & Sc.*, *Mont.*

Aquatic, floating. Sporangium subsessile, immersed in the perichætial leaves; peristome double; inner peristome cancellated.

558. The pleurocarpous *Fontinalei* answer to *Ripariei* in the acrocarpous series. They have the same floating habit, but they are evidently connected with many pleurocarpous mosses, as *Cryphæa*, *Spiridens*, &c. The peristome of the common *Fontinalis* is a most elegant microscopic object, from the beautiful cancellation of the inner teeth, and the cross bars or trabeculæ, as they are called, of the outer teeth, which are united above in pairs, and are slightly twisted when dry. *Dichelyma* differs from *Fontinalis* in its dimidiate calyptra, and its frequently exserted sporangia. These are mosses of the northern hemisphere. No species appears in the Antarctic Flora, or in that of New Zealand. The common *Fontinalis* has received the specific name of *antipyretica*, because it is used in Sweden to stuff the space between the chimney and the walls to prevent fire, which it is said to do effectually from its not being inflammable. Its triquetrous stems are very curious, and the keeled leaves, clasping at the base, call to mind those of *Drepanophyllei*, though they are quite destitute of nerves. Sometimes the leaves are cloven along the keel, when they resemble the oblongo-lanceolate leaves of *F. squamosa*.

5. Cryptotheciei, *Br. & Sc.*

Pilotrichei, *Müll.*

Stems cylindrical ; leaves imbricated ; calyptra mitriform ; peristome single or double.

559. This, again, is a small tribe consisting of a few genera only, and these probably ought to be reduced in number, as, in many natural genera, species with a single and double peristome cannot be properly separated from each other. Thus *Cryptotheca* differs from *Cryphæa* only in the single peristome. *Esenbeckia* differs principally in the plicate, serrated leaves. *Cryphæa* differs from *Meteorium* in the small conical calyptra and immersed sporangia. The habit of *Meteorium*, moreover, as the name implies, is pensile ; while *Pilotrichum* has a rigid erect habit. Several species of *Meteorium* and *Cryphæa* are found in New Zealand, and other southern regions. *Cryphæa heteromalla* is a common British moss, exhibiting very well the characters of the tribe. This some-

times grows in water, and has then, as indeed it has at all times in some measure, the habit of *Fontinalis*. A few species of *Neckera* are referred to *Pilotrichum*, but true *Neckeræ* have flattened pinnate stems, and a cuculliform calyptra. *Daltonia*, which is represented in Ireland by *D. splachnoides*, is distinguished by its ciliated calyptra; its cylindrical stems seem to associate it with *Cryphæa* better than with *Hookeria*. One of the most curious genera belonging to this tribe is *Dendropogon*, Schimper,* founded upon a moss which hangs down in great masses from trees in Mexico, like *Meteorium* or *Usnea*. It is an admirable substance for packing, and first became known to Schimper from being used as packing for a collection of succulent plants. The fruit is nearly that of *Cryphæa*, but the perichætial branches are so elongated that the moss is cladocarpous, after the fashion of the cladocarpous *Grimmiæ*. *Spiridens* connects this tribe with *Hypnei*. The habit is that of *Hypnum triquetrum*, but the sessile fruit and conical calyptra are those of *Cryphæa*. *S. Reinwardtii* is found in Java, Tahiti, and the Philippine Islands, and sometimes is a foot or more in length. In fact, it is one of the finest species of the order. Müller has proposed a distinct tribe for a plant related to *Cryphæa*, under the name of *Erpodiaceæ*, on account of its flat bifariously imbricated stems, gymnostomous sporangia, and loose reticulation. It is founded on *Anœctangium Domingense*, Bridel.†

6. HOOKERIEI, *Br. & Sc.*

Stems mostly flattened, creeping, irregularly branched; leaves reticulated; areolæ mostly large; sporangium horizontally cernuous, thick, succulent on a succulent elongated peduncle; calyptra campanulate, smooth; peristome double.

560. The mosses belonging to this tribe are remarkable for their succulent texture. The mitriform calyptra at once separates them from *Hypnei*, apart from their peculiar habit. *Hookeria lucens* is one of our most beautiful mosses, and very striking, from its large pale shining green leaves. It is

* Bot. Zeit., 1843, p. 377, tab. 1.

† Bot. Zeit., 1843, p. 773.

not, however, in general a plant of flat countries. A few species only are European. Authors, indeed, are by no means agreed as to the limits of the genus. Within the above definition, by which *H. lucens* and *læte-virens* are included, numerous species occur in New Zealand and Australia, including Tasmania, and in other southern regions. The calyptra is always mitriform, but occasionally it is deeply ciliate at the base. A few species, as *H. robusta*, are among the larger mosses. *H. nigella* is remarkable for its dark dingy hue. Two or three of the species included in the Antarctic flora have erect sporangia, but are separated from *Leucodontei* by their mitriform calyptra. Many forms occur in other parts of the world, and in very different climates, but till the genera and affinities are more settled it is difficult to speak of individual species. In any arrangement it must be remembered that habit is of more consequence than the peristome; but even this must not be attended to, to the exclusion of evident affinities, while mere analogues are placed in close connection. The association of the white mosses, called by authors *Leucobryaceæ*, with *Sphagnei* is an instance of this kind; but though the leaves agree in colour, and in some points of structure, the fruit is totally unlike, so that nothing can be more unnatural than their juxtaposition.

7. NECKEREI, *Mont.* OMALIEÆ, *Br. & Sc.*

Stem mostly compressed and pinnate; peduncle usually short or wanting; peristome double; calyptra dimidiate.

561. The pinnate branching is the most striking distinction of these plants from *Hookeriei*, from which they are moreover separated by the cuculliform calyptra, which is frequently pilose. The species are perennial, and many of them are amongst the most elegant cryptogamic productions. The foliage is often undulated, and the sporangium sunk in the perichætial leaves or shortly pedunculate. *Omalia* contains such *Hypna* as *H. trichomanes*, with flattened pinnate or subpinnate stems, and has unequal cernuous sporangia with an inner peristome destitute of intermediate cilia between the divisions, as in *Leskea;* while in *Neckera* the sporangium is straight and erect. A few species only are European.

Several species of *Omalia* occur in New Zealand, and two of *Neckera*, of which one, *N. pennata*, a species which occurs sparingly in Great Britain, is almost cosmopolitan. There is no species in the Antarctic Flora. *Trachyloma* is distinguished by its dendroid habit, and the leaves not being oblique. The ramification is pinnate, which separates it from *Climacium*, in addition to the absence of lacunose cilia. *Neckera* is a genus of hot countries, and abounds in India and the hotter parts of South America. A few species only occur at once in the Old and New World.

8. HYPNEI, *Br. & Sc.*, *Mont.*

Stems mostly imbricated and cylindrical; sporangium cernuous; peduncle elongated; peristome double; calyptra dimidiate.

562. After the genus *Hypnum* has been cleared of the species with erect perithecia, and of a few others differing strikingly in habit, there remains a vast mass of species distributed widely over the world, of which nearly one hundred occur in England alone. They vary immensely in size, and are divisible into several sub-genera; but a little experience at once separates true *Hypnei* from all extraneous mosses. Trees, rocks, and dry or shady banks, abound with them. The stems are for the most part creeping, but are branched so as to make thick tufts. Occasionally the branches are pinnate, but even then they are easily distinguished from *Neckera* by their cernuous sporangia. The species are monœcious or diœcious, and in the latter case the fruit is often extremely rare. In a few species only the stems are flattened and the leaves distichous; in many, however, they are secund without any flattening of the stem. The modifications of the leaves, peduncle, calyptra, peristome, &c., are almost infinite, and must be studied in detail. One or two exotic genera also occur, of which it is needless to state the peculiarities in this place.

9. LEUCODONTEI, *Br. & Sc.* ISOTHECIIS, *Br. & Sc.*, *inclusis.*

Stems cylindrical; leaves imbricated; areolæ small; sporangia erect; peristome single or double; calyptra dimidiate.

563. The cuculliform calyptra distinguishes these plants

from *Cryptothecei*, in addition to their different habit. They are distinguished from *Hypnei* by their erect sporangia, to which the exceptions are not important. *Leptodon Smithii* has the sporangium slightly cernuous, but that is a species which the short peduncle evidently separates from *Hypnei*. In one or two *Leskeæ* also the sporangium is suberect, and the same may be said of *Isothecium*. I can discover no characters by which *Leucodontei* can be separated from *Isothecii*, and therefore both are included here in one tribe. *Leucodon*, *Antitrichia*, *Leptodon*, and *Anomodon* are the British genera belonging to the former group, while *Pterogonium*, *Isothecium*, *Climacium*, *Cylindrothecium*, and *Leskea* belong to the latter. Most of these genera depend upon modifications of the peristome, and in some cases on slight differences of habit. *Leskea*, for instance, differs from *Hypnum* not only in the erect sporangia, but in the absence of intermediate cilia in the inner peristome. *Climacium* deserves especial notice on account of the tree-like habit of the species, accompanied by a peculiarity in the inner cilia, which are distinctly lacunose. Several species of this tribe, especially of the genus *Isothecium*, occur in the southern hemisphere, but some are found also in the tropics. *Leptodon Smithii* is widely distributed. *Pterogonium hirtellum* has the leaves sprinkled with short hairs, a rare character amongst mosses.

10. Rhizogoniei, *Mont.*

Leaves distichous, perichætial shoots springing from the base; calyptra dimidiate; peristome single or double.

564. This little tribe consists of two genera, *Rhizogonium* and *Hymenodon*, which differ greatly from *Hypnum* in habit. The stems are for the most part erect, clothed with distichous often margined leaves, and bearing the perichætial branches only at the very base, as if the moisture at the base of the tufts were necessary for their development. The tribe is therefore analogous to *Geocalyceæ* among the *Jungermanniæ*. *Hymenodon* differs in having only a single peristome and a straight sporangium. Six species of *Rhizogonium* are recorded in the Flora of New Zealand, and one of *Hymenodon*. Other species occur in Brazil and Java. *Rhizogonium spiniforme*

has a wide range both in the Old and New World, but does not extend north of Florida. In *R. mnioides*, the sporangia are not positively basal. This species also extends to New Grenada from Cape Horn, from whence it has a lateral distribution. Müller asserts that the peristome of *Hymenodon* is internal, or in other words that it arises from the spore-sac, and not from the inner wall of the sporangium; but this is not confirmed in the Flora of New Zealand.* Müller has proposed in the same place a new genus, *Rhizopelma*, founded on *Leskea Novæ Hollandiæ*, but he had seen only barren specimens. Montagne's distinction of barren and sterile shoots, and of the frondose nature of the former, is not borne out by examination, though there is some analogy between these plants and *Drepanophyllei.*

11. PHYLLOGONIEI, *Mont.*

Leaves distichous, equitant, lineari-areolate; sporangium suberect, equal; calyptra submitriform; peristome simple.

565. We have here distinct analogues of *Depranophyllei*, of an equally elegant form, and glittering like gold when dry. The shoots are flat, the leaves rhomboidal and distichous; sometimes nerveless, sometimes nerved but equitant. The peduncle is about as long as the fruit; the columella large; and the peristome single, consisting of sixteen broad almost membranous teeth. The calyptra completely covers the sporangium, and is multifid at the base, and slightly pilose. They are mosses of warm countries, and natives for the most part of the tropics.

12. HYPOPTERYGEI, *Mont.*

Leaves trifarious, the third row smaller than the others, and resembling amphigastra. Fruit mostly lateral beneath the proper leaves, sometimes axillary. Calyptra conical.

566. In this most curious tribe we have a third row of leaves, smaller, and of a different form from the other (Fig. 99, 109), resembling the amphigastra, which we have seen so commonly in *Jungermanniæ*. *Hypopterygium* and *Cyathophorum* are the oldest genera of the tribe; but to these two genera, *Lopir*

* Bot. Zeit. 1847, p. 802.

dium and *Catharomnion* have been added by Hooker and Wilson, in the Flora of New Zealand. *Hypopterygium* has the peristome of *Hypnum; Lopidium*, of *Leskea;* while *Catharomnion* has a simple internal row of teeth. The species are natives either of the Southern Islands and Chiloe, or of warm countries. *Cyathophorum pennatum* is one of the most beautiful of mosses, and is remarkable for its short curved peduncles inserted in a tumid vaginula. The fruit (Fig. 109) is produced in the axils of the lateral leaves, which are large and of a dark green.

13. RACOPILACEI, *Hook. & Wilson.*

Stems creeping, subpinnate; leaves mostly dimorphous; intermediate leaves smaller, seated on the upper side, minutely areolate; calyptra mitriform, pilose at the base.

567. Allied to the last, but the amphigastra are differently placed, and the calyptra is remarkable for its hairy base and margin. The habit, moreover, is very different, approaching that of *Hypnum*, which the species resemble in the curved unequal sporangia. Like the last two tribes, they belong either to the Southern Islands or to hot climates, as the Philippine Islands.

568. Mosses are no less variable than other Cryptogams, and are therefore frequently very difficult to distinguish. Not only will the same species exhibit great diversity in the size, mode of branching, form and nervation of the leaves, but the characters of even the peristome itself are not constant, as I have already pointed out; nor is it always easy to assert whether the calyptra is mitriform or dimidiate, as this may depend upon the form assumed by the sporangium after the peduncle has raised the calyptra up. If, indeed, it is taken into consideration in what very different climates and situations these Cryptogams occasionally grow, we shall be prepared for quite as much change as actually appears, and shall be very cautious in the absence of marked characters of separating species. The greatest cause, however, of perplexity in the study of mosses arises from the loose manner in which particular species are assigned to genera, and the vague notions which exist as to affinity. In the present state of our knowledge

of mosses, it seems impossible to make any arrangement which shall be quite satisfactory. That which I have adopted is certainly open to many objections, and the same may be said of every existing classification.

ALLIANCE V.

FILICALES, *Berk.*

FILICALES *and* LYCOPODALES, *Lindl.*

Spores producing a prothallus by germination or by cell-division homologous with germination. Archegonia formed in the prothallus, producing, after impregnation, a distinct sporiferous plant.

569. The two groups of Cryptogams associated by Dr. Lindley, under the names *Filicales* and *Lycopodales*, are so closely united by means of *Ophioglossaceæ*, that I have no hesitation in comprising all under one head, characterised by the formation of a distinct prothallus. Even if the general denomination of *Filicales* should not be approved, as applied to all the natural orders included under it, their intimate relation is not invalidated by the adoption of a name which might seem to indicate a closer resemblance between the tribes associated under the Lycopodal group, and that of Ferns, than actually exists. *Ophioglossaceæ*, however, scarcely bear a closer resemblance to Ferns than *Salvinia;* and while their æstivation is straight, certain *Lycopodales*, as *Pilularia*, possess a circinate æstivation.

I. FILICES, *Juss.*

Fronds circinate when young, simple or variously divided, the fertile often of a different form from the sterile, bearing on their under side little heaps (sori) of subglobose sporangia, mostly furnished with a distinct and often elastic ring, naked or invested by a distinct cover (indusium), springing mostly from a vein, but sometimes extending to the neighbouring parenchym; rhizoma creeping or after a time erect and subglobose, or cylindrical and arboreous, sometimes climbing.

570. No plants are more easily recognised than Ferns, notwithstanding the multitudinous forms under which their fronds appear, and their diversity of growth. The circinate æstivation and hypophyllous fruit, added to the peculiar habit and venation, at once establish their nature. *Stangeria* (Fig. 1) has, indeed, the same venation and æstivation, but the strobili-

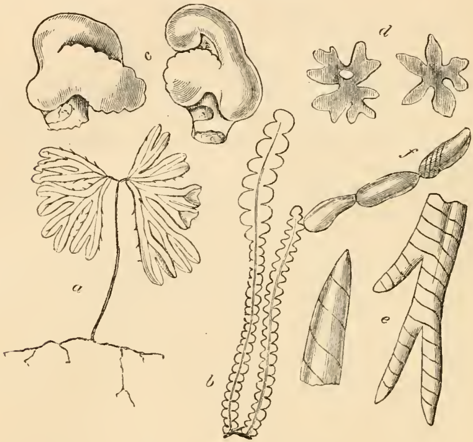

Fig. 110.

a. Hymenophyllum Lyalli, natural size. From a New Zealand specimen.

b. Two pinnæ of *Gleichenia microphylla*, the tip of one of which is expanded by a hot moist atmosphere.

c. Young leaves from bulbs of *Marattia alata*, to show the large foliaceous processes of the base of the stipe. Magnified.

d. Horizontal section of cysts of *Olearia hirta*, magnified.

e. Ends of ditto. The three last from Kew.

f. Cysts from a tree-fern from Guatemala, magnified.

form fruit is at once decisive; and though the filmy, loosely cellular leaves of *Hymenophyllum* (Fig. 110, *a*) resemble *Symphyogyne*, there is no resemblance in the fruit. These, in fact, are mere cases of analogy, and deceptive only on superficial examination. In a few cases only, as in *Acrostichum*, the fruit is produced on the upper side; but the structure in these cases, and the whole character, are so decidedly the same, that there is no difficulty. Indeed, in one or two very rare instances, fruit is produced on the upper side in genera where it is usually hypophyllous. Dr. Hooker has shown me, for example, a specimen of *Asplenium Trichomanes*, from Genoa, in which there is a sorus on the upper surface; and in a late number of the Kew Garden Miscellany Sir W. J. Hooker has figured a Fern from Ceylon, with the fruit on the upper side.* In one or two genera, again, the sporangia are wholly destitute of a ring, whether more or less complete; but in these cases the other characters are such as to remove all doubt about affinity. The sori, moreover, are in normal cases confined to the veins or veinlets, whether at some point in their course or at the tip; but in a few genera the sori of neighbouring veins unite, and extend from the vascular bundles to the neighbouring parenchym, or the sporangia are scattered indefinitely.

571. The spores of Ferns, which are produced like those of *Muscales*, by cell division within the sporangia, and are therefore unattached, are variously shaped, according as the separation in the mother-cell takes place at an earlier or later period, and variously sculptured. They consist of two coats containing a grumous mass. On germination, the outer coat bursts,

* This is figured under the name of *Polypodium anomalum*, of which genus it has the characters. But Sir W. J. Hooker is almost convinced that the plant is a mere monster of *Polystichum vestitum*. The tissue is certainly much closer than in that species, as far as I can judge from the comparison of sections of the leaves of two specimens only. There is no doubt that the sori are really produced on the upper side, and that the frond is not reversed like the leaves of *Alstrœmeria* or the laciniæ of *Schizæa*, as the structure of the soriferous side is essentially that of the upper and not of the under side.

and the inner is elongated and protruded (Fig. 14, *a*), and at length by cell-division expands into a thin marchantioid frond or prothallus. On the under side of this two kinds of bodies are formed, one of which produces spiral ciliated spermatozoids (Fig. 111); the other are archegonia sunk in the cellular tissue, resembling those of Muscales. These were first described by Nägeli, and have since been frequently recognised. Leszczyc-Suminski witnessed the entry of the spermatozoids into the

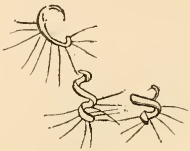

Fig. 111.

Spermatozoids of *Pteris aquilina*, after Thuret.

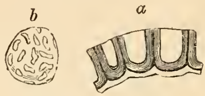

Fig. 112.

Actiniopteris radiata.
a. Part of ring, magnified.
b. Spore, magnified.

archegonia, and, impressed with the Schleidenian theory of impregnation in Phænogams, believed that the broader end was changed into a young plant, of which the radicle was directed towards the base of the archegonium, a direction exactly contrary to that which prevails in Phænogams. It is now, however, ascertained that the cell at the base of the archegonium, after impregnation, gives rise to the new plant. This is gradually developed, and is of different duration in different species. Wherever it is perennial, however, it bears, year after year, a new crop of sporangia without any further impregnation. The impregnation takes place only in the archegonia of the prothallus. No successive crops of archegonia are formed, as in mosses.

572. It was stated under mosses, that there is no good reason to believe that the parts of the peristome are modified leaves. There does not seem the same objection in Ferns to the sporangia being altered fronds, provided the ring be not supposed to represent the mid-rib, which is plausible enough where it forms a great circle, but not where it is apical or very

oblique. The strongest arguments in favour of the notion are derived from the production of bulbs or young plants upon the fronds, especially as sometimes happens in place of sori. It is true that the sporangium at first consists of a single cell, but so does the leaf of a Phænogam, and the spores are formed by cell-division, exactly like the pollen in an anther, which is confessedly a metamorphosed leaf. I do not, therefore, see the same objection to the application of the doctrine of metamorphosis in this case as in Mosses, and more especially

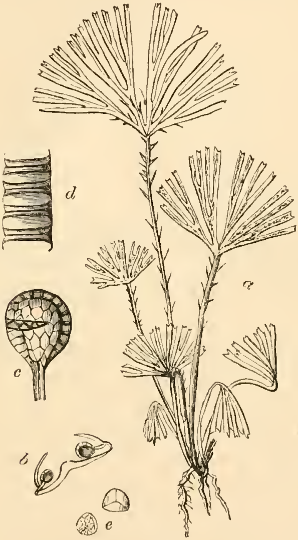

Fig. 113.

a. Actiniopteris radiata. From a specimen gathered at Beeder, by Lieut. E. S. Berkeley. Natural size.

b. Section of leaf showing indusium and insertion of sporangia.

c. Sporangium.

d. Part of ring.

e. Spores. The four last more or less magnified.

when it is considered that the archegonium here produces something like an embryo.

573. In no branch of Cryptogams, not even in mosses, are the principles on which the systematic arrangement is formed more vague and uncertain than in Ferns. One founds his divisions on the indusium (Fig. 113, *b*), another on the ring (Fig. 113, *d*), another on the venation, and another on the nature of the rhizoma. Though all these points are valuable, none is of such predominant importance as to exclude the others. If the obliquity of the ring were strictly attended to, the closest allies would be separated. The near affinity of *Polypodium* and

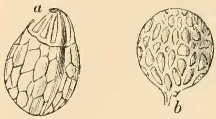

Fig. 114.

a. Sporangium of *Aneimia aurita*, Sw. From Hook. Cent., tab. 3.
b. Ditto of *Osmunda regalis.*

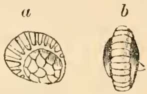

Fig. 115.

a. Sporangium of *Gleichenia Cunninghamii*, Hew.
b. Ditto of *Hymenophyllum pulcherrimum*, Col.
Both received from Dr. Hooker.

Polystichum speaks strongly against too strict attention to the indusium. One of the strongest instances of its uncertainty is afforded by *Polypodium rugulosum* and *Hypolepis tenuifolia,* species which have an extremely wide distribution, and which are, probably, one and the same Fern. But allowing the two to be distinct, there is great variation in the former, as regards the position of the sori. In some specimens they recede from the margin, in some they are close up to it, as if prepared for an indusium. And then touching *H. tenuifolia*, I have specimens given to me by Dr. Hooker, from six different localities, in one of which the involucre is incomplete; in another herbaceous; in another cartilaginous; in a fourth herbaceous, with a membranous edge; in a fifth membranous; and in a sixth indifferently membranous and herbaceous. It is highly injudicious, therefore, to lay too much stress upon the indusium.* Nor, again, is the position of the sori always decisive. We have seen how it varies in *Polypodium rugulosum.* In like manner, as the frond gets broader, the indusia, in other Ferns, retire from the margin, and thus *Darea,* as exemplified by *Darea prolifica* in Norfolk Island, becomes *Asplenium.*† The venation, though evidently of great importance, from its close connection with the fruit, is too subject to variation to afford incontestible general characters, however valuable it may be in particular instances. The same venation occurs in groups of very different affinities, as in *Leptogramma* and *Asplenium, Goniopteris* and *Stenogramma, Nephrodium* and *Meniscium,* to take examples indicated by Dr. Hooker. It will not, therefore, do for the distinction of larger groups of genera. Dr. Hooker has figured, in his paper on the Vegetation of the Carboniferous Period as compared with that of the present day,‡ two pinnules of *Diplazium Malabaricum,* in which the venation is totally different. In the one the veinlets meet; in the other they are perfectly distinct. Without fruit, they might be referred to *Callipteris* and *Digrammaria.* He has also shown, on the other hand, that in *Cyclopeltis Presliana* and *C. semicordata* the only sure distinction consists in the fact that, while in both the unbranched veins which spring from the costa have a sorus at their tip, the right-hand veinlet of the branched veins, which alternate with the unbranched, in the one case bears a sorus at its tip--in the other, in its centre.

574. As regards the different forms of Rhizoma, I doubt very much whether any particular type of formation attends the rejection or retention of the stipes.§ This does not seem to me

* If *Polypodium anomalum* be really a state of *Polystichum vestitum,* as intimated above, it would be most important to ascertain the early condition of the sori.

† This is well illustrated by *A. bulbiferum,* as cultivated at Kew, where different parts of the same frond exhibit extreme differences of development.

‡ Memoirs of the Geological Survey of Great Britain, vol. 2, part 2, p. 387.

§ Those Ferns in which the stipites are articulated with the rhizoma. as *Angiopteris evecta,* are called by Mr. J. Smith *Eremobrya;* those in of the same importance as in Endogens and Exogens. To take the cases of deciduous-leaved tree ferns and *Marattiaceæ*, nothing can be more different in the whole group than the disposition of their tissues. That the rhizoma will in some cases afford good characters, as also the disposition of the vascular bundles in the stipes, can scarcely admit of doubt.

575. The Rhizoma, as just said, varies greatly in character. In some cases, as in *Marattia*, the vascular bundles are regularly distributed through the whole mass; in others they are disposed in a single circle, as in *Nephrodium Filix Mas*, or with neighbouring smaller bundles, as in *Phymatodes leiorhiza;* in others they are reduced, as in *Trichomanes reniforme*, to one central bundle; while in others they are disposed on either side of hard plates, as in *Pteris aquilina;* or a few larger than the rest, as in many tree ferns, are closely surrounded with dense tissue, and disposed symmetrically round the axis, sometimes forming a closed cylinder, as in *Dicksonia antarctica.** In some cases they seem to be quite insolated, giving off no bundles to the fronds, this office being performed by smaller fascicles, as in the tree ferns figured by Mohl in Martius's work on the Cryptogams of Brazil; while in others they as evidently supply the stipites.

576. The general disposition of the tissues in the more highly organized ferns may be given as follows:—Round the scars of the stipites cavities exist filled with stellate brown tissue. The cortical stratum consists first of cuticle, then of parenchym, and then of hard brown parenchym,† with thick punctated walls. The inclosed cylinder is filled with softer cellular tissue, containing many cysts gorged with resinous matter, and various bundles of vascular tissue, attended by pale pleurenchym. The larger bundles, which are flattened and variously curved, are surrounded by dense tissue like the inner layer of

which the stipe is not articulated, as *Nephrodium Filix Mas*, *Desmobrya*. Contiguous genera, as *Nephrolepis* and *Nephrodium*, *Stenochlæna*, and *Polybotrya*, sometimes belong to the two divisions.

* I have a portion of a tree fern from Silhet, given me by Dr. Hooker, in which the cylinder is nearly perfect. See also Lind. Veg. King.

† This tissue is sometimes parenchym, sometimes prosenchym.

the bark, and arranged in a circle symmetrically round the axis with short interspaces, through which the other smaller bundles dispersed in the central mass give off branches into the stipites, while others exist in the space between the bark and larger masses. These latter form a more or less perfect cylinder round the axis, and are altogether distinct from anything in Endogenous stems; besides which, there is not that crossing of the fascicles characteristic of Endogens. The vessels themselves, which are always scalariform, though varying greatly in size, are accompanied by cellular tissue, and surrounded by elongated pale wood cells (pleurenchym), beyond which is parenchym mixed with resinous cysts. The hard coat which incloses the vessels with the pleurenchym and parenchym, belongs to the general mass of cellular tissue, and not to the wood which is represented by the minute quantity of pleurenchym. The structure of other ferns is more or less in accordance with this; but the disposition of the bundles and of the hard attendant tissue is infinitely varied. In *Pteris aquilina*, for instance, the hard tissue which in the tree ferns incloses the principal vascular bundles, is disposed in two curves, on either side of which the vascular bundles are arranged, each inclosed by a thin coating of denser tissue than the general mass. Sometimes these two arcs meet at one extremity, sometimes at both, especially where a stipe is given off. Besides the two main masses of dense tissue, there are many scattered fibres. In other cases this peculiar dense tissue is altogether scattered about in little fibres, like those of *Pteris aquilina*, just mentioned; in some, as in *Olearia hirta*, it is either converted into or replaced by curious cysts (Fig. 110, *e*,*f*), which display a fibrous structure. In many cases, as in *Phymatodes leiorhiza*, where the bundles are arranged in one principal circle, with a few outliers, it appears to be entirely wanting. In this and many other ferns there appears to be scarcely any distinct cortical layer, the transition to the general mass of cellular tissue being almost imperceptible.

577. Not only is there great difficulty in arranging ferns satisfactorily, but it is even more difficult to determine the limits of species. If large series are examined, it is asto-

nishing how many species are referrible, without doubt, to one common type. Thus, *Schizæa flabellum* and *S. dichotoma*, with many varied intermedials, notwithstanding their immense difference of form, beyond all doubt, belong to one and the same species. But there are other cases in which, though the identity is not so evident, the limits are absolutely incapable of definition. *Asplenium monanthemum*,* *trichomanes*, *oblongatum*, and *viride*, all run into each other, and the same may be said of numerous other groups of species. The only difference between *A. obtusatum* and *A. marinum*, a plant of extremely wide distribution, is the confluence of the upper pinnæ into one broad terminal pinna ; in other respects they are absolutely the same. Take, again, such species as *Asplenium bulbiferum* and *laxum*, supposed once to constitute two distinct species, till intermediate forms appeared in Tasmania, and compare a good series of both with *A. flaccidum* and it will be impossible to say of certain individuals to which species they belong. Such examples might with ease be multiplied. That circumstances will alter the appearance of species is clear from the fact that *Lomaria Patersonii*, which is cultivated at Kew, produced for years simple fronds, but at length became divided ; and I have seen in the same garden the minute pinnules of a *Gleichenia* expanded to three times their normal length and breadth, and the margin at the same time unfolded, when placed in a hot damp atmosphere (Fig. 110, *b*).

578.† "There are few or no natural orders of plants so eminently sensitive to changes in the amount of vapour in the atmosphere as the Ferns ; and we consequently find them to be, to a remarkable degree, natural hygrometers, and their luxuriance a certain proof of the dampness of a climate. Moisture, both of the soil and air, appears, indeed, absolutely to regulate their development, both in luxuriance and abun-

* This species has sometimes three or more sori.

† I am indebted to Dr. J. D. Hooker for this valuable account of the distribution of ferns, which would have been much extended did the limits of this volume permit. This, however, is far from being the only instance in which I am obliged to his vast fund of knowledge and experience.

dance; and this development attains its maximum where to these conditions is added a wooded, hilly or mountainous, and rocky country. That this is the case in limited areas is familiar to the local observer, and is nowhere more remarkably evidenced than in Britain, as may be seen by a comparison of the Fern floras of the drier eastern and damp western shores of our kingdom, of the firths of Forth and Clyde, or of the estuaries of the Thames and Severn, of Dublin and Killarney; and that it equally obtains over large areas is obvious from many facts in their distribution. Thus, it is in the moist warm islands of the Indian Ocean, Pacific, and Gulf of Mexico, that the order reaches its maximum; and whilst the north temperate hemisphere produces scarcely one hundred species and no approach to a tree fern, in corresponding latitudes of the southern hemisphere a luxuriant fern vegetation prevails, as in Tasmania, New Zealand, West Chili, and Juan Fernandez; and whereas arborescent ferns attain their boreal limits in N. lat. 37° (and this only in the humid valleys of the Himalaya), various species are found in perfection in S. lat. 40° to 50°.

579. "Shade, although a very necessary condition for most ferns, is yet of secondary importance; for in a damp soil and moist climate ferns often carpet the soil even when exposed to the full light of the sun; and a few species of *Adiantum*, *Pteris*, *Gymnogramma*, and *Cheilanthes*, inhabit the dry rocks of South Africa, India, and Australia.

580. "The Arctic limit of ferns is found in America, at Minto Inlet, lat. 70° N. and long. 120° W., whence *Cystopteris fragilis* was brought by the officers of Captain McLure's expedition on the Greenland coast; and at Disco, where also *Polystichum Lonchites* was found by Dr. Lyall. On the east coast of Greenland *Aspidium fragrans* was the most northern fern found by Captain (now Major-General) Sabine. In Arctic Europe, no ferns have been found in Spitzbergen or Nova Zembla; only fourteen in Iceland; and on the mainland (Lapland), about fifteen species. Proceeding eastwards, the increasing drought and inflection of the isothermals in Northern Prussia, and still more in Northern and Central Asia, remove the limits of ferns almost as far south as the Altai.

581. "Owing to the sharply contrasted seasons of temperate continental North America, there are even fewer ferns in that vast tract of country than there are in Central Europe: only fifty species are mentioned in Hooker's Flora Boreali-Americana, and as many in Gray's Flora of the North United States; whereas Britain alone contains thirty-six.

582. "Advancing eastward, we find that the European Flora contains only sixty species; and in the Flora of the whole Russian dominions, extending from the Baltic to the Pacific, and from lat. 40° to the Arctic circle, scarcely as many are found.

583. "Of the number of ferns indigenous to the tropics no accurate estimate has yet been published; but we know that nearly three hundred species have been collected in the Philippine Islands, and that there are perhaps two hundred in Java, and about as many in British East India.

584. "In the south temperate zone New Zealand presents by far the richest assemblage of ferns, nearly one hundred and twenty species, besides many well-marked varieties, occurring in its islands; and of these eight are tree ferns, and several others sub-arboreous. In the dreary islands of the Antarctic Ocean ferns still predominate; twenty-one species inhabit Fuegia and the Falkland Islands; one forms matted tufts on the sterile soil of Kerguelen's Land (where only sixteen flowing plants have been found); and about as many inhabit Lord Auckland's and Campbell's Islands to the south of New Zealand.

585. "Of the extended distribution of the species, a few examples must suffice: thus *Cystopteris fragilis* has been met with in the temperate and colder humid regions of both hemispheres in the Old and New World, extending from the Arctic circle to the mountains of Tasmania. *Gymnogramma leptophylla* has a scarcely less extensive range, and is found in warmer latitudes; whilst *Pteris aquilina* is found in almost all temperate and sub-tropical countries, under, however, many different names. Of the fifty N. United States ferns, fifteen are also British, and fully one half of the British species are also found in the Himalaya mountains. Comparing the Fern Flora of Britain

with that of its antipodes, New Zealand, we find several common to both; which is the more remarkable from these two localities being the richest in species in their respective latitudes. Again, the ferns of Tasmania are, with few exceptions, identical with those of New Zealand; and lastly, the occurrence of the rather common Australian and New Zealand *Gymnogramma rutæfolia* in the Pyrenees (where it is extremely scarce), and nowhere else in the whole world, so far as is known, is one of the most remarkable facts in the distribution of plants that has ever been made known. Amongst a few anomalies in the diffusion of the order are the dissimilarity of the Ferns of St. Helena and Ascension, a fact which admits of no known explanation, and the presence of the tropical *Trichomanes speciosum* in South Western Ireland, which may, however, be readily accounted for by the humidity of that locality and its geographical position.

586. "The genera of ferns are founded on such arbitrary characters, that it is impossible to draw any conclusions from their distribution; the majority, however, of the temperate genera are found in all temperate and tropical latitudes, and the tropical genera are for the most part common to both the Old and the New World. *Lomaria* and *Gleichenia* are almost the only well-marked genera common in south temperate regions, which are not found in the northern."

587. The uses of ferns are more numerous than those of mosses, though they are not very important. They doubtless help to form soil with other cryptogams, but their property is rather to take possession altogether, than to aid in the production of other plants. Several of them, when burnt, produce ashes, useful for manure, or, as crude matter, for the chemists. The long creeping rhizoma of a variety of *Pteris aquilina* was formerly much used in New Zealand for food. It abounds in starch and mucilage; but if the New Zealand variety is not more palatable than our own, it is a very undesirable food.* The large rhizoma of *Marattia salicina*

* The rhizoma of our own form of *P. aquilina* when roasted has just the slimy consistence, taste, and odour of ill-ripened Brinjals when cooked, than which nothing can be a worse compliment. The great

is eaten when prepared in the same way. The soft cellular substance of *Cyathea medullaris* affords a better article of food, for which purpose some other species are occasionally used. *Adiantum Capillus Veneris* is an ingredient in Capillaire; but other species, as *Asplenium Adiantum nigrum*, are often substituted. *Nephrodium Filix mas* is still used as a valuable remedy for tapeworms. A *Polypodium*, in Peru, has some reputation in fevers and other maladies; and the down from the stem of some *Cibotium* has lately been much recommended as a styptic, under the name of Penghawar Djambi:* its action is probably merely mechanical, as chemical analysis produces nothing active. A similar substance is gathered in Madeira from *Dicksonia Culcita* to stuff cushions. The rhizoma of *Phymatodes leiorhiza* when dry smells and tastes like liquorice. A small species of *Grammites* is so odoriferous when dry, that it is used by the Indian women of Peru as an agreeable perfume.

588. It remains only to say a few words on fossil ferns. Ferns abound in the coal measures and in some other formations; but they very rarely bear fruit, and are therefore not capable of identification with our own. The species are apparently very numerous. Dr. Hooker has shown, in the Memoir quoted above, how impossible identification is from the venation only, and instances the rarity of fruit in the tree ferns of New Zealand as a circumstance in favour of the supposition that many of them were arboreous. Trunks of tree ferns are found in a very perfect state, according in structure perfectly with our own. Corda figures some with comparative analyses

objection, however, to this as an article food is the nauseous mucilage. If the rhizoma, after being washed and peeled, is scraped so as to avoid including the hard walled tissue, and then mixed with a sufficient quantity of water, the mucilage will be dissolved, and after a few hours may be decanted. A little colourless, tasteless mucilage will pass off on a second washing, and the residue, when baked, is far from unpalatable, and must be very nutritious. It is far better than Cassava Bread, and would not be despised in time of famine. See also Hook. Him. Journal, i., p. 293.

* Pharm. Journ., Nov. 1856; Chemische Untersuchungen des Penghawar Djambi in Vierteljahresschief für prakt. Pharm., vol. 5, 1856.

of recent species in his Beiträge zu Flora der Vorwelt. He has also figured very curious fruit in *Senftenbergia elegans* Fig. 116), approaching in structure that of *Aneimia,* and more imperfectly in *Hawlea pulcherrima,* allied to *Mertensia.* There is also, in Linn., vol. xi., a figure of a Fern in fruit, apparently allied to *Mertensia,* but the fructification is very anomalous. A few other species have been found in fruit, but none perhaps in so perfect a condition as *Senftenbergia* of Corda.*

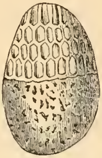

Fig. 116.

Senftenbergia elegans, Corda. Sporangium after Corda.

a b

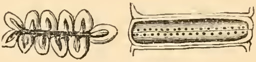

Fig. 117.

a. Sorus of *Angiopteris evecta.*
b. Ditto of *Danæa Elliptica.*
Both slightly magnified; the former from Kew, the latter from a St. Vincent's specimen in Hook. Herb.

589. In the following notes, I have for the most part adopted the arrangement of Presl. as modified by Sir W. J. Hooker, in his work on the Genera of Ferns. The characters are in general abridged from Presl., with such alterations as seemed desirable or were necessary for the prescribed limits of this volume. I have also made great use of Mr. J. Smith's excellent memoir on the Genera of Ferns in Hooker's Journal of Botany, vol. 4, and Hooker's London Journal of Botany, vols. 1 & 2.

* For further information consult Brongniart's article in Orbigny's Dictionary.

FILICES.

- Ring obsolete or imperfect.
  - *Marattiaceæ.*—Sporangia coriaceous, ringless, more or less confluent.
  - *Osmundaceæ.*—Ring imperfect; sori naked.
  - *Schizæaceæ.*—Ring terminal, sori in spikes or on resupinate lobes.
  - *Parkeriaceæ.*—Ring absent, or dorsal and imperfect; sori marginal, continuous.
- Ring vertical.
  - Indusium absent.
    - *Acrostichaceæ.*—Sporangia diffused; indusium 0.
    - *Tænitideæ.*—Sori linear, extending to the interstices; indusium 0.
    - *Grammitaceæ.*—Sori linear, confined to the veins or veinlets; indusium 0.
    - *Polypodiaceæ.*—Sori apical; indusium 0.
    - *Vittariaceæ.*—Sori seated in the grooved margin, which simulates an indusium.
  - Indusium present.
    - *Adiantiaceæ.*—Sori linear, marginal, apical; indusium spurious, formed by the revolute margin.
    - *Dicksoniaceæ.*—Sori globose, apical; indusium lateral, bivalvate.
    - *Davalliaceæ.*—Sori apical, inframarginal; indusium univalvate.
    - *Aspleniaceæ.*—Sori epineural; indusium persistent, lateral; margin free.
    - *Aspidiaceæ.*—Sori subglobose; indusium free except at the point of attachment.
    - *Peranemaceæ.*—Indusium inferior, at length lobed or ciliate.
- Ring oblique or eccentric.
  - *Hymenophyllaceæ.*—Frond cellulari-reticulate.
  - *Cyatheaceæ.*—Sporangia pedicellate, bursting laterally.
  - *Gleicheniaceæ.*—Sporangia sessile or subsessile, bursting longitudinally.

1. Marattiaceæ, *Kaulf.*

Danæaceæ, *Ag.*, *Lindl.* Agyratæ, *Swartz.* Poropterides, *Willd.*

Sori dorsal, oblong or annular. Sporangia ringless, coriaceous, more or less combined into a lobed mass, with or without an indusium.

590. The ringless sporangia of the ferns included in this tribe are so different from those which occur in other species, that they have been considered as constituting a distinct order. They are, however, so evidently ferns by habit, by their circinating æstivation and venation, by the origin of the sori from the veins, &c., that, notwithstanding this difficulty, I cannot make up my mind to separate them, especially since the ringless sporangia of *Parkeria;* and the very imperfect development of the ring in *Osmunda* and *Todea* seem to connect them with more normal ferns, as do the several gradations of structure in the different genera. The want of a ring is not, however, the only peculiarity. The young frond is involved in two appendages belonging to the base of the stipes, which perform the functions of a volva. This, however, is not more truly a volva, than that of so fungoid an aspect which occurs in some *Balanophoræ*, but which really arises from the valvate æstivation of the lower leaves. In *Angiopteris evecta*, for example, the edges of the two foliaceous lobes wrap over each other long before the bursting forth of the frond; and from what I have seen in other plants of the order, it appears very doubtful whether they are ever continuous, as figured by De Vriese.* If a bulb (Fig. 118, *c*) of *Marattia alata* be examined, the base will be found composed of two or more imbricating concave scales, within which the first frond is more or less completely inclosed by two lobes arising on each side at the base. These are never circinate, and cannot be regarded as inferior pinnæ, but rather as appendages of the rhizoma, as they grow beneath the point at which the stem disarticulates. In *M. cristata*, the edge at length becomes green, foliaceous,

* Monographie des Marattiacées, par W. H. de Vriese et P. Harting. Leide and Dusseldorf, 1853.

and variously lobed and crisped. These organs, as appears from the observations of De Vriese and my own examination, are very sparingly supplied with vascular tissue. The rhizoma is generally a large globose mass, rough with the processes from which the stipes have fallen. It sends out a few large aerial roots, and consists of loose cellular tissue abounding in starch, and small scattered bundles of vessels. In many *Marattiaceæ*, as, for example, in *Angiopteris evecta*, the surface of the stipites and the appendages is sprinkled with pale linear patches, which have been compared to the lenticelles of Phænogams. It has been said that several layers of cells shell off from these patches. The surface, however, is quite continuous with that of the rest of the stipe or its appendages, and in the dry stipe lines of the pale tissue radiate from these spots into the surrounding parenchym. The absence of colour depends upon the nature of the endochrome of the cells. It may be remarked that in Vriese's book the species are multiplied beyond any reasonable bounds, a fact which everyone will allow who has had an opportunity of examining a really good series of specimens.

591. It was said that the sporangia in this tribe are more or less confluent. In *Angiopteris* they are less so than the other genera, being confluent only at the very base. The sori are seated towards the tips of the veins, and the sporangia, which are obovate and burst longitudinally, are disposed in a row on each side of a little linear receptacle projecting from the vein, so as to form a narrow ellipse (Fig. 117, *a*). *Marattia* has "the sori at the ends of the veins just within the margin; each consists of two opposite parallel plates, with convex backs and plane faces, the latter marked by vertical gashes, opening into as many cells containing spores." The two rows of sporangia are at first combined into a common solid mass, but this, after a time, splits in the direction of the vein, and becomes bivalvate. *Eupodium* is distinguished from *Marattia* by the narrow indusium, which was sessile in that genus, being pedicellate. In *Danæa* the two rows are intimately combined with cellular tissue into a chambered mass, each chamber containing two sporangia, and the spores are discharged by

round pores.* In *Kaulfussia* the two rows of sporangia are combined into an orbicular cup. The sori, moreover, are scattered over the frond. Most of the species are tropical. They occur in either hemisphere, and in the Old and New Worlds. *Marattia salicina* occurs in Norfolk Island and New Zealand, as well as in warmer localities. Several forms are found amongst fossil remains, as proved by the structure of the rhizoma. The leaves of *Angiopteris evecta* are said to be used as a perfume in the Sandwich Isles, where the rhizoma is eaten, as that of *Marattia* is in New Zealand.

2. OSMUNDACEÆ, *R. B.*

Sporangia pedicellate, hypogenous, or paniculate, furnished with a broad dorsal imperfect ring, and bursting vertically.

592. In *Marattiaceæ* there was no trace whatever of a ring; in the present tribe, on the back of each sporangium (Fig. 114, *b*) there is a disc lighter than the rest, and composed of hexagonal tissue, which represents the ring, which is still very imperfect. Though the sporangia are less complicated, the frond is as highly developed as in other ferns, and the species may certainly be reckoned as amongst the nobler of the order. Few ferns, indeed, are more beautiful than the species of *Leptopteris*, and *Osmunda regalis* is, perhaps, the finest of all European forms. In *Leptopteris* the sporangia are placed upon the veins, without, however, forming distinct sori, and the fronds are beautifully translucent. In *Todea*, the frond is coriaceous, and the sporangia hypogenous; while in *Osmunda* the upper part of the frond is converted into a spike covered with the sporangia. *Leptopteris* is almost peculiar to New Zealand. *Osmunda* is widely distributed. *O. regalis* is found in many parts of the world, and the common United States species, *O. cinnamomea*, which is, perhaps, not distinct, in several parts of India. In one or two species, as *O. javanica* and *O. Vachellii*, though the veins are forked,

* If, however, a transverse section be made through the middle of the sorus in *Danæa* and *Marattia*, it is almost exactly the same in each, looking like a double row of parenchymatous cells. The sporangia of *Danæa* are completely soldered together in the middle, above which they are free.

greater or less latitude. Fée, however, includes the helicogyrate ferns also in the general denomination of *Polypodiaceæ*, dividing them into twenty-six sections. Brongniart, on the contrary, in his article on ferns, in Orbigny's Dictionary, who adopts *Polypodiaceæ* as a tribe, divides it into nine sections, *Acrostichcæ*, *Tænitideæ*, *Grammitideæ*, *Polypodiaceæ*, *Aspidieæ*, *Asplenieæ*, *Adianteæ*, *Dicksonieæ*, and *Woodsieæ*. It is, in fact, of little consequence whether the divisions be called tribes or subtribes, provided it be borne in mind that all the divisions are not of equal value. However they may be apportioned, the arrangement of authors, in most cases, is essentially the same, though each authority may differ from the others in some few particulars.

596. I begin, then, with *Acrostichaceæ*, which differ from all other ferns, in the sporangia occupying not merely the veins of whatsoever order, but the perenchymal interstices themselves. In *Tænitideæ*, indeed, the sori encroach upon the parenchym, but merely by the junction of neighbouring sori in a direct line. The fertile fronds are mostly different in form and aspect from the sterile fronds, and are generally more or less contracted, sometimes so much so as to suggest the presence of an indusium, which, however, does not exist. All the species were formerly included under *Acrostichum*, which is now broken up into several genera, with more or less propriety, from the venation of the sterile fronds (for that of the contracted fertile fronds is often obscure), and other characters. *Elaphoglossum*, for instance, has simple oblong or linear lanceolate leaves, with simple or forked veins, whose tips are free and clavate. In *Polybotrya* the tips of the radiating or pinnate veins are free, and the sporangia occupy one or both sides of the spikelike segments of the fertile fronds. *Stenochlæna* is very nearly allied, and differs from *Polybotrya* in the petioles being articulated with the rachis. *S. heteromorpha*, like most of the species, climbs lofty trees by means of the stout rhizoma. The fronds are very different in different parts of the plant. This is the only species of the tribe which occurs in New Zealand. *Olfersia* agrees with *Polybotrya* in the character of its fertile fronds, but differs in habit and the

connected veins. The sporangia occupy both surfaces of the fertile frond, the lobes of which are linear, entire, or pinnatifid. In *Acrostichum* the fronds are coriaceous, the venation is reticulate, and the sporangia are widely diffused, but confined to the under side. *Platycerium* has thick, spongy fronds, widening upwards, shaped more or less like the horns of elks, arising from imbricated orbicular or subcordate sterile fronds, sometimes depressed, sometimes ascending. The veins, moreover, of the fertile fronds run down to a stemlike base, different from anything in the whole order. The sporangia occur in patches, mixed with stellate scales, anticipating those of *Niphobolus*. Specimens are often seen in collections, growing against a wall, or attached to a piece of board. *Campium* has the interstices of the costæ traversed by arcuate veins like *Meniscium*. In *Pœcilopteris* there are strong costæform veins, connected by network. In *Gymnopteris* the primary veinlets divide the interstices of the veins into parallelogramic areæ, which are themselves reticulate. The species of this tribe are, with few exceptions, tropical or subtropical. It has not one representative even in New Zealand.

6. TÆNITIDEÆ, *Presl.*

Sori naked, linear, continuous, or rarely interrupted, seated upon the veins or veinlets, from whence they extend to the neighbouring parenchym.

597. This tribe is very near to *Acrostichaceæ*, but differs because the sori do not cover the surface indiscriminately, though they run out in a narrow line over the parenchym, which latter circumstance distinguishes them from *Grammitaceæ* and *Polypodiaceæ*. *Tænitis** and *Notholæna* are the best-known genera. In the former the veins are reticulate, and the sorus parallel with the margin, but at a distance from it. In the latter the sorus is marginal, but the veins forked or pinnate. The under side of the fronds in this genus is sometimes covered with white farinaceous powder. Many species are densely tomentose or squamose, circumstances which bring them near to *Gymnogramma*, while other

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points indicate affinity with *Pteris* and *Cheilanthes*. *Pteropsis* differs from this in the reticulate veins. In *Pleurogramma* the sori occupy either side of the costa, running over the interstices of the pinnate veins. In *Lomatogramma* the veins form nearly equal hexagonal areæ, and the sorus is one broad continuous marginal patch, approaching in character the diffused sori of *Acrostichaceæ*. Finally, in *Drymoglossum* the veins are reticulate, with free veinlets in the meshes, and the sori marginal and continuous, but linear, and sometimes confined to the apex. Most of the species of this tribe are tropical or subtropical. One only appears in the Flora of New Zealand.

7. GRAMMITACEÆ, *Presl.*

Sori naked, linear, elongated, rarely short, seated on the back of the veins or veinlets. Sporangia shortly pedicellate. Rhizoma for the most part creeping, sometimes subglobose.

598. The elongation of the sori is not the only character by which these plants are distinguished from *Polypodiaceæ;* but whereas in the latter the sorus is always seated at the tip of a vein or veinlet, it is here as constantly placed on the back. From *Tænitideæ* they differ in the sori being confined to the veins, and not extending over the interstices. The tribe consists of two sections, allied respectively to *Grammitis* and *Hemionitis*. The former has the sori seated on the simple veins, the superior or some secondary veinlet; in the latter they occur on all the veinlets of the branched veins.

599. As regards first the allies of *Grammitis, Monogramma* has a single sorus at the tip of the costa, which is at length veiled by the contracted frond. This is so like *Pleurogramma* as to be easily confounded. In that genus, however, the sori are on each side of the costa, a fact which can only be ascertained by careful examination. *Grammitis* has the sori on the middle or rather towards the tip of the veinlets, and consequently oblique, by which character again it is distinguished from *Pleurogramma*. In *Stenogramma* the lower veinlets anastomose; in *Meniscium,* of which one South American species is arborescent, they form, when confluent, short curved lines. *Synammia* differs from *Grammitis* in the

anastomosing veins. *Loxogramma* has an internal reticulated venation, and sori produced on the elongated sides of the areolæ. The absence of costæform veins and free veinlets distinguishes it from *Selliguea*. *Polytænia* has several very long continuous sori between the rib and the margin, deeply immersed, and seated on the longitudinal veins. The frond is, as it were, pinched up on either side of the sori.* In *Antrophyum*, the sori, though reticulate, are sunk as in *Polytænia*. *Diblemma* is remarkable for having scattered sori in addition to the marginal, with reticulated venation. *Selliguea* is intermediate between the two sections, differing from *Grammitideæ* in having linear sori seated between the nerves. It bears the same relation to them that *Phymatodes* does to *Polypodiaceæ*.

600. We come now to the allies of *Hemionitis*. In *Gymnogramma* the sori are on the forked veins or veinlets, and at length frequently become confluent. In *Hemionitis* the veins are much branched and reticulated, and to a great extent occupied by sori. In *Leptogramma* we have costæform pinnate veins, with free parallel veinlets. The sori, as in *Gymnogramma*, are medial. *Ceterach* technically belongs to this tribe, in consequence of the absence of an indusium, but the place of this is supplied by the abundant scales, and its affinities seem to be rather with *Asplenium*, to which it is very closely related, than with *Grammitis*. This is one of the instances in which the presence or absence of an indusium must not be taken as decisive of affinity. Though this tribe contains many tropical and subtropical forms, we have a sprinkling of more temperate species. Both the New Zealand species of *Gymnogramma* occur in Europe, and other species of the tribe occur in Madeira. They do not, however, extend far north. None appear in the Flora of the Northern United States, nor in Great Britain, if *Ceterach* be excluded.

601. Many of the species of *Gymnogramma* are remarkable for the white or variously tinted yellow meal with which the under side is clothed. As many varieties combining the cha-

* It is to be observed that in *Vittaria* the sori are sunk in a marginal groove, and in *Pteropsis* at a little distance from the margin. Here they are not single.

racters of two or more species, come up spontaneously in cultivation, it has been conjectured that they are truly hybrids. It is obvious that in the case of such minute bodies as the archegonia and antheridia, it is very difficult to make experiments. Hybridization, if it take place at all, must be between the prothallus of one species and that of another; and if experiments are to be convincing, they must be directed to seedlings soon after the prothallus has begun to expand.

8. POLYPODIACEÆ, *Presl.*

Sori globose, naked, seated at the apex of a vein or veinlet on the disc of the frond, rarely medial. Sporangia on long peduncles. Receptacle punctiform.

602. This is one of the largest of all the tribes, the study of which requires much care, as the indusia in *Aspidiaceæ* are so deciduous that a mistake is easily made.* As regards affinity, however, it is quite certain that the presence or absence of an indusium does not deserve all the importance which has been assigned to it. The tribe is distinguished from *Grammitaceæ* by the globose sori, but this, again, is a character which must not be too strictly limited. The tribe is divisible into three sections, allied, respectively, to *Lecanopteris*, *Polypodium*, and *Struthiopteris*.

603. The first section is very small. It is characterised by the marginal sori being seated on the hypertrophied teeth. *Lecanopteris* has anastomosing veinlets. The sori are produced on exserted concave indusiiform marginal lobes, which are reflexed like the shields of *Nephroma*. In *Calymmodon* the veins are simple, and a part of the tooth of the frond is turned over the sorus. The few species are tropical.

604. The second section abounds in species. In these the margin is even, and is not turned over. The sori are seated at the tips of the veins. In *Goniopteris* the pinnate costa-like vein bears short pinnules, each of which supports a round apical sorus, so that the sori form double lines between each pair of pinnæ. The sporangia, moreover, are hispid, and the spores rough instead of smooth. *Stenosemia* is sometimes

* *Amblia*, Presl. = *Phanerophlebia*, for example, is an Aspidiad which has lost its involucre.

referred to *Acrostichaceæ*, but the scattered round or oblong sori forbid this union. *Goniophlebium*, combined with *Marginaria*, has the sori parallel with and near to the costa, so as to form a single or double line on either side; they are always produced at the tip of the lower veinlet or the free veinlets in the areolæ. The sporangia are surrounded by paraphyses, some of which are simply clavate, but others end in peltate scales. In other cases the whole frond is rough, with peltate scales, which are elongated on one side. Similar scales, but elongated in two opposite directions, with intermediate teeth, accompany the fruit. *Campyloneuron* has the pinnate veins connected by transverse veinlets, little branches from which bear the sori. This is combined with *Cyrtophlebium* by Smith, and distinguished from *Niphobolus* by its smooth fronds and distinct sori. *Dictyopteris* is distinguished from several subsequent genera by having no free veinlets in the areolæ. *Pleopeltis* has broad, targetlike scales, mixed up with the sporangia, performing the functions of an indusium. *Phlebodium* agrees with *Pleopeltis* in the angularly or arcuately anastomosing veinlets, producing on their outer side or angular commissures two or more conniving or transversely combined veinlets, which are sporangiiferous on their combined apices or line of junction, but the sori are not covered at first with scales. *Phymatodes*, with which *Drynaria* is combined, has the sporangia sprinkled with obtuse hairs, elliptic even spores, and the sori seated between the pinnate veins at the tips of inconspicuous veinlets. It contains some of the finest species of the tribe. *Aglaomorpha* or *Psygmium* is remarkable for the sori being placed in the centre of the contracted lobes of the fertile frond, as in the first section. The difference between the lobes of the sterile and fertile fronds is very remarkable. *Dryostachys* has remarkably large oblong or quadrangular sori, forming a row on either side of the costa, between the veins of the semi-fertile fronds; the veinlets form a curious reticulate plexus. *Dictymnia* "has simple coriaceous fronds, with internal anastomosing veins, which cannot be seen without maceration, with large naked superficial sori;" and *Arthropteris* has uniserial globose sori terminating the free veinlets of the forked veins, which are thickened above and do not reach the margin. The pinnæ are articulated to the rachis, as is the stipe to the rhizoma. The most observable point, however, is that the New Zealand species, *A. tenella*, has no indusium. That organ exists in the two other species, which are evidently congeneric, a striking proof of the comparatively small value of the indusium. *Polypodium anomalum* has the sori on the upper side, but the plant is so like *Polystichum vestitum* that it is probably a monstrous form in which the indusium is not formed. *Niphobolus* has several series of sori between each pair of veins, and the tips of the paraphyses are remarkably stellate. *Synammia*, finally, has oblong sori seated on the back of the lowest free vein. A large portion of the species are tropical or subtropical, but *Polypodium vulgare* is one of the commonest ferns of temperate countries, and a few other species are far from uncommon. Several genera and species also occur in the southern hemisphere, either peculiar to it or extending from warmer latitudes. Two of these are climbers.

605. It remains only to notice the third section, which contains *Struthiopteris*, one of the most remarkable genera in the tribe, and which occurs both in Europe and North America. The fertile and sterile fronds are dissimilar, and the membranaceous reflected margin of the former simulates an indusium. The sori, it is to be observed, are really seated on the back of the pinnate veins, and the margin of the frond, though scarious, is turned over several sori. *S. germanica* is quite hardy, and is often seen in gardens.

9. VITTARIACEÆ, *Presl.*

Sori naked, immersed in the very margin of the frond, which simulates an indusium. Sporangia pedunculate.

606. Care, of course, must be taken in estimating the species which belong to this tribe, so as not to confound the edge of the frond with an indusium. The sori are deeply sunk, and according to the mode in which they are seated the species simulate other genera. *Vittaria* has the sori immersed in a distinct groove, at the very edge of the frond, without a trace of an indusium ;* *Prosaptia*, in little cupshaped cavities lead-

* Smith separates *Tæniopsis* from *Vittaria*, because the sori are

ing to the tip of the veins. These processes are not, however, of the nature of indusia, but are hard and coriaceous, and entirely of the same substance as the rest of the frond. The species of *Prosaptia* are analogues of *Davallia*, but not, I I think, very closely related; nor do I see how it can be reduced to *Polypodium*. The tribe is essentially tropical or subtropical.

10. ADIANTIACEÆ, *Pr.*

Sori linear, lineari-oblong, or globose, mostly marginal, seated on the tips of the veins, in most cases soon becoming confluent. Indusium spurious, formed from the reflected margin of the frond. Rhizoma globose or creeping, rarely arboreous.

607. The transition from the indusiate to the nonindusiate ferns is made by this tribe, which is very near to *Dicksoniaceæ*. The indusium is, however, essentially spurious, being nothing more than the reflected margin of the frond. Those cases require to be carefully distinguished where the indusium, though marginal, springs from a nerve, and is perfectly distinct, which is the case in *Actiniopteris* (Fig. 110, *b*). This false indusium may be either scarious or coriaceous, but more frequently the former; it is, in fact, the same organ with the spurious indusium of *Dicksonia*, the true indusium being suppressed. The tribe is divisible into two sections, containing the species more especially allied to *Lonchitis* and *Adiantum*.

608. The first is known by the sori being constantly seated in the sinuses of the frond, the indusium being lunate or linear. *Lonchitis* has reticulate venation, *Hypolepis* pinnate. Of the various characters assumed by the indusium of the latter, and its confluence with *Polypodium*, I have already spoken in the general observations. The species are tropical or subtropical. *Hypolepis tenuifolia* extends to New Zealand.

609. The second section has linear or subglobose sori, at first distinct, but very soon becoming confluent, seated at the margin of the frond. *Haplopteris* has distant parallel simple veins, springing from the costa; the indusium is infra-marginal,

situated in a groove parallel with the margin, and not in the margin itself, and remarks that the simple venation separates them from *Polypodiaceæ*.

and scarcely to be distinguished from that of ferns, with a true indusium springing from a marginal vein. *Lomaria* has pinnate forked veins. The sori and indusia are truly marginal. The rhizoma very rarely forms a distinct caudex. *Pteris* is scarcely different from *Lomaria*, except in the foliaceous fertile pinnules and laciniæ, narrower indusium, and fertile fronds similar to the sterile; whereas in *Lomaria* the fertile fronds are narrower. *Campteria* differs from *Pteris* in the lower veins forming a distinct arc. *Litobrochia* has reticulate veins; *Amphiblestra* strong, riblike veins, with reticulated interspaces. In *Allosorus* the margin of the frond is revolute, and the sori are covered by the crenato-plicate margin and indusium. To this genus *Pteris aquilina* is referred by Presl. *Platyloma* has oblong laterally confluent sori, so as to form a single broad continuous marginal sorus. *Cryptogramma* scarcely differs from *Allosorus*, to which genus *Ceratodactylis* is very near, but the sori are longer, and the habit distinct. The sterile part of the frond is like *Osmunda*, and the fertile part like *Ceratopteris*, consisting of contracted pinnæ, with revolute indusiiform margins. *Onychium* is somewhat similar, but the frond is not altered and contracted. *Jamesonia* has radiating free veins, and round, confluent sori, forming one central sorus to each pinna, the margin of which is revolute, and forms a common indusium. In *Cassebeera* the sori are seated two together, under each crenation of the frond, so that every spurious indusium covers two sori. In *Adiantum* the pinnæ are mostly trapezioid, and the veins are flabellato-pinnate. The genus is close to *Pteris*, and often difficult to distinguish, and more by habit than by character. *Hewardia* differs remarkably from *Adiantum* in the reticulate venation. In *Ochropteris* the sori are seated on the tips of from two to four converging veinlets, from which the indusium springs, and which form its base; whereas in *Adiantum* the sporangia are produced on the under side of the indusium. Its habit is very peculiar. *Cheilanthes* has subglobose distinct sori, and a narrow marginal indusium, sometimes so narrow as to appear, at first sight, deficient. The genus is with difficulty distinguished from *Adiantum*, which passes into *Cheilanthes* by *Ochropteris*.

Several species of *Cheilanthes* are beautifully farinose underneath. Amongst many tropical and subtropical species we have here many essentially temperate, and others which have an extremely wide distribution, as *Pteris aquilina*, which occurs variously modified in all parts of the world. Nearly a fourth of the New Zealand ferns belong to this section.

11. DICKSONIACEÆ, *Presl.*

Sori globose, submarginal, seated at the tip of a vein or veinlet; indusium lateral, persistent, bivalvate, the lower valve formed by the true indusium, the upper by the altered tooth of the frond folded back. Often arboreous.

610. This tribe is allied to *Cystopterideæ*, as regards the true indusium, and to *Adiantiaceæ*, so far as the margin of the frond conduces to the formation of the indusium. In *Balantium* the indusium forms a cup, to which the false indusium makes a sort of lid. *Cibotium* is distinguished by its nearly equal valves, whereas in *Dicksonia* they are unequal. *Leptopleuria* has a coriaceous true indusium placed at the very margin. It differs principally from *Dicksonia* in all the parallel veins being fertile, and not a select few only. *Patania* has a saucer-shaped indusium, covering only the base of the sorus, the true and false indusia being completely connate. *Cystodium* is remarkable for the cuculliform false indusium, the margins of which are connivent, while the true indusium is plane. *Sitolobium* differs from *Dicksonia* in its creeping rhizoma and delicate texture. *Thyrsopteris* has semiglobose sori, with coriaceous cupshaped indusia, disposed in a paniculate thyrsus. The fertile frond is, in fact, reduced to a mere rachis, like *Trichomanes pluma*, Hook. The sterile fronds have simple or forked veins in the same disc. It forms a slender caudex. *Deparia* is a *Thyrsopteris* with the parenchymatous border developed, so that the cups are marginal, after the fashion of the inflorescence of some *Xylophylla*. This tribe contains some of the finest of the tree ferns. *Dicksonia antarctica* has a uniform girth of 12 feet, through its height of 40. *Dicksonia squarrosa* reaches the farthest south of all the tree ferns. *Dicksonia lanata* sometimes forms a distinct caudex, but not always. In fact, tree ferns in gene-

ral vary much as regards the dimensions of their caudex, according to favourable or unfavourable circumstances. The rhizoma of *Cibotium Barometz* is covered with long tawny hair, a circumstance which gave rise to the fable of the Scythian lamb, half animal, half vegetable. It was said to perish, if not already the prey of wolves and other carnivorous animals, after it had consumed all the food within the small semicircle of which alone it had the range, being always united to the parent. The species belong principally to the tropics and southern isles. *Thyrsopteris* is confined to Juan Fernandez. The fibrous coat of the trunk in *Dicksonia antarctica* is sliced by the New Zealanders and used in constructing houses.

12. DAVALLIACEÆ, *Gaud.*

Sori inframarginal, globose, or linear, seated at the tip of a vein or veinlet; indusium lateral, semiorbicular, oblong or linear, persistent, scarious, the upper margin free.

611. The resemblance of *Davalliaceæ* to the *Cystopteris* section of *Aspleniaceæ* is confessedly very close, and without attention to the nervation they are not easy to distinguish. In this tribe, however, the indusium is more constantly seated at the tip of a vein or veinlet; whereas in the ferns just mentioned it is situated in the middle. In *Davalliaceæ*, moreover, the indusium is adnate through a considerable part of its circumference, and is persistent. From *Dicksoniaceæ* they differ in the want of an accessory indusium. *Microlepia*, *Saccoloma*, and *Davallia*, all agree in this respect. *Leucostegia* has the sori seated in the sinus of the laciniæ, with a scarious indusium. One species seems at first sight to differ from other ferns except *Polypodium anomalum*, and certain *Acrostichaceæ*, in having the sori on the upper surface; but the fact is, that this is paler, and looks like the under surface, because the margin of each pinnule curves upwards. *Microlepia* differs from this principally in habit. *Humata* has a coriaceous indusium, and veinlets thickened upwards. *Davallia* is known by its tubular indusium, and *Saccoloma* has a small linear special indusium, with a spurious indusium formed by the reflected margin, and thus passes into *Dicksoniaceæ*. The genera just enumerated

pave the way to *Lindsæa* and its allies, which have linear marginal sori, for the most part continuous, but sometimes regularly interrupted. The indusium opens towards the margin of the frond, and not away from it, as in *Pteris*, a consequence of its not being merely the altered margin. The sori, moreover, connect the tips of the veins and veinlets. In *Lindsæa* we have frequently trapeziiform or cuneate pinnæ, resembling somewhat those of *Adiantum*. *Schizoloma* has the sori parallel with the margin, as in *Lindsæa*, but the venulation is angularly anastomosing, instead of flabellate. *Isoloma* has a marginal bilabiate indusium, and differs from *Lindsæa* in having deciduous pinnæ. *Dictyoxiphium* has simple lineari-lanceolate fertile fronds, inframarginal sori, and compound anastomosing veinlets, with variously directed free veinlets in the areolæ. *Synophlebium* differs from *Schizoloma* in the eccentric midrib. This, again, is mostly a tropical or subtropical division. *Davallia canariensis* is a well-known object of cultivation in our conservatories. One species extends to New Zealand, and two of *Lindsæa*.

13. ASPLENIACEÆ, *Presl.*

Sori globose, linear-oblong or more frequently linear, seated on the back, rarely at the tip of a vein or veinlet; indusium lateral, persistent, free on the side which is opposite to the margin of insertion; rhizoma subglobose, rarely creeping, more rarely still forming a low unarmed caudex.

612. This tribe is at once distinguished from *Aspidiaceæ* and *Davalliaceæ* by the lateral persistent indusium, which is free opposite to the margin of insertion. This freedom, moreover, does not take place by the mere dehiscence of the indusium, but is essential to the structure. The tribe is divisible into five sections, allied respectively to *Scolopendrium*, *Diplazia*, *Asplenium*, *Blechnum*, and *Cystopteris*.

613. The first is distinguished by the sori being approximated and parallel on the proximate sides of two contiguous parallel veinlets, the free margin of both being in consequence opposite. The sori in *Scolopendrium* look like one, but are really double, each with its own indusium. The indusium is not, in fact, a single indusium fixed on either side and bursting

in the midst. In *Antigramma* the veinlets are reticulate, but the twin sori still face each other; in *Camptosorus*, however, the sori diverge. *Scolopendrium officinarum* is one of our most common ferns and rather variable. The frond is sometimes forked, and sometimes the margin is curiously waved and crisped. One or two other species of the section, as *Camptosorus rhizophyllum*, belong also to temperate climates.

614. The second section, which is tropical, in India and America, consists of genera allied to *Diplazium*. In this the sori are bilateral or double, so that the indusia open in opposite directions. With the double sori are often intermixed perfectly simple individuals. Those with simple sori, it is said, may be distinguished from *Asplenium* by the circumstance of their opening towards the main nerve, while in *Diplazium* they open from it. I fear, however, that this character is not constant. *Anisogonium* differs from *Diplazium* in the return of the pinnate veinlets to the main veins, so as to form little arches. *Oxygonium* has entire pinnæ, with fascicles of veinlets anastomosing near the margin, and there producing free veinlets. *Callipteris* has costæform veins, the lower opposite veinlets anastomosing so as to form an angle, and the upper free.

615. The third section contains the large genus *Asplenium*, and one or two genera which have been separated from it. All have pinnate veins, and the sori, whether more or less linear, are attached to the back of a simple vein or the primary fork of the vein, or indiscriminately. The edge of the indusium is sometimes ciliated. In *Neottopteris* the tips of the veinlets are joined by a transverse continuous anastomosing veinlet. *Allantodia* has a vaulted sausage-like indusium, with reticulated veinlets. *Ceterach*, as observed before, has no indusium. *Hemidictyon* is distinguished by "the exterior margin of the reticulated venation being combined by a continuous vein parallel with and close to the margin, and also by its plane indusium." *Plenasium* is the mere barren frond of *Osmunda Javanica*. Like many large genera, *Asplenium* has representatives in most parts of the world, and some of these very

widely distributed. With the exception of *Ceterach*, the other genera are tropical. The old *Asplenium Nidus*, familiar as an object of cultivation and one of the noblest of ferns, belongs to the genus *Neottopteris*.

616. *Blechnum* is the typical genus of the fourth section. *Athyrium*, which comprises our *Filix fœmina*, though in some measure approaching the next tribe, is distinguished by the decidedly linear junction of the indusium with the frond. In *A. latifolium*, however, it is often curved so as to make the indusium reniform. The straight sori are, indeed, the rarer of the two. The indusium is at length reflected by the growth of the sporangia. *Doodia* and *Woodwardia* are two closely allied genera. In both the sori are short and parallel to the costa on transverse veins. In *Doodia*, however, the indusium is flat, and in *Woodwardia* immersed and convex. In the former the veins and veinlets are raised beneath and more distinct from the costa. *Blechnum* has the sori more or less confluent, with the free side of the indusium towards the costa. The Brazilian *Salpichlæna* is distinguished by its climbing habit, and by the venules being combined by a transverse slight infra-marginal vein. The indusium, moreover, is very long and cylindrical, and bears part of the sporangia upon its line of attachment. *Blechnum* is easily confounded with *Lomaria*, in which the indusium is formed from the altered margin of the frond, while in *Blechnum* it is perfectly distinct. *Actiniopteris* (Fig. 113, *a*) appears to be a true ally of *Asplenium*, though its marginal indusia appear at first to indicate a different affinity.* The genera are indifferently tropical or temperate. *Doodia* extends to New Zealand, and both that genus and *Woodwardia* occur in the United States. *Athyrium* and *Blechnum* are both tropical and extratropical, varying much in size.

617. The section of which *Cystopteris* is typical is somewhat analogous to *Cyatheaceæ*. The indusium of *Cystopteris*, a well-known European genus, though not confined to the northern hemisphere, is suborbicular, and fixed by a lateral

* The origin of the indusium from the vein is not properly expressed in the woodcut as it was in the original drawing.

inferior point. It is therefore only on a superficial view similar to the indusium of *Cyathea.* The sori are, in fact, like those of the next tribe, but the insertion of the indusium is different. *Acrophorus* is a *Cystopteris* with apical sori. The genus is founded on a Java species. *Onoclea* is remarkable for the pinnæ being contracted into berry-like globes. There is some difficulty about the nature of the indusium, as the pinnules are so hard and coriaceous as to mask the structure. *Ragiopteris* is the same genus with *Onoclea. O. sensibilis* is a well-known American species, the fronds of which were formerly supposed to die if a single pinnule were squeezed; but this does not appear to be confirmed by modern observation.

14. ASPIDIACEÆ, *Presl.*

Sori globose or more rarely oval, seated on the middle of a vein or veinlet, rarely apical; indusium superior, orbicular, and peltate, or reniform, or ovali-elliptic, fixed to a central or slightly lateral point, or by a longitudinal crest, but free all round; rhizoma creeping or sub-globose.

618. This is an enormous tribe, abounding in species, forming the old genus *Aspidium,* and divisible into two distinct sections, one of which contains the immediate allies of *Nephrodium,* the other those of *Aspidium, Lastrea, Oleandra. Nephrolepis,* and *Nephrodium,* which all belong to the first section, and differ principally in the details of the nervation. *Lastrea,* for instance, is distinguished from *Nephrodium* by the veins remaining distinct, while in *Nephrodium* they inosculate. In *Nephrolepis* the sori are seated at the tips of the lower exterior veinlets, a character which, however, occurs in some species of *Nephrodium,* of a very different habit, and not having the petioles articulated with the rachis, like true species of *Nephrolepis. Oleandra* has the tips of the parallel veinlets curved upwards, and forming a slightly thickened margin, and is distinguished, moreover, by its simple fronds, which are articulated close to the rhizoma. *Nephrolepis tuberosa* is singular for the tubers on the rhizoma. These are $1\frac{1}{2}$-inch long, ovoid, subterraneous, subtranslucid, filled with a firm mucous subtranslucent substance. They have a circle of

vascular bundles, forming a sort of balloon as they proceed from a common base below, and then converge to the apex. *Oleandra neriiformis* is remarkable for its erect shrubby rhizoma, which rises to a height of from four to six feet, and bears whorls of fronds ; it grows in open spots.

619. The second section is familiar, as far as the name goes, to every lover of Ferns, though the genus *Aspidium*, as now limited, is confined to a few tropical species, with compound anastomosing veinlets, producing free veinlets in various directions. *Sagenia* differs principally in the absence of the latter. *Polystichum* contains species with free veinlets, and a peltate indusium. *Cyrtomium* has medial sori, the lower veinlet free, and the upper anastomosing, and producing free veinlets on their outer sides and angular junctions. *Phanerophlebia* differs from this merely in more of the veinlets being free. *Fadyenia* has reticulate and anastomosing veinlets, and apical biseriate sori. *Mesochlæna* or *Sphærostephanos* is distinguished from *Nephrodium* by the linear sori. The glandular margin of the indusium occurs also in some species of *Nephrodium*. *Pleocnemia* differs from *Sagenia* principally in the gigantic habit. *Didymochlæna* requires especial notice, on account of its oblong elliptic sori and indusia, fixed to the frond by a longitudinal crest; an exaggeration of the usual reniform indusium. It is also said to be arboreous ; but old plants of *D. sinuosa*, a Brazilian species, exist in the Kew Garden, which have not assumed the habit of a tree fern. *Matonia*, referred formerly to *Cyatheaceæ*, appears more properly to be placed here, on account of its superior indusium, which covers only a definite number of sporangia, thereby showing a strong analogy with *Gleichenia*. The stout rhizoma is said to be creeping, though six or eight feet long. Most of the genera are tropical ; but *Lastrea*, *Nephrodium*, and *Polystichum* have numerous European species, or species which belong to temperate regions. These are often extremely variable, nor can the same reproach be withheld from many tropical species.

15. PERANEMACEÆ, *Presl.*

Sori globose, pedunculate, or seated on the middle of the superior vein; indusium inferior, scarious, at length splitting into several lobes; receptacle generally very small.

620. A small tribe consisting of only a few genera. *Peranema* or *Sphæropteris* has a large globose rhizoma, and pedunculate sori; the tips of the veins are clavate and glandular. *Diacalpe* differs only in its apparently sessile sori. *Physematium* has sessile sori with a nearly entire indusium and sub-globose rhizoma. *Woodsia* differs from *Physematium* in its beautifully laciniated indusium, and contains two of our rarest and most interesting Ferns. *Hypoderris* is very close to *Drynaria*, and distinguishable only by its very obscure but perfect cupshaped indusium, like that of *Woodsia*, from which genus it differs in its anastomosing not simple veinlets. *Thyrsopteris* and *Cibotium* are inserted here by Presl, but their proper place is amongst *Dicksoniaceæ*.

16. HYMENOPHYLLACEÆ, *Endl.*

Indusium cupshaped or bivalvate, formed partly of the frond, or arising from and threaded by the excurrent costa, to the base of which are attached the sporangia mixed with paraphyses.

621. In consequence of the membranaceous reticulated fronds resembling those of *Symphyogyna* (Fig. 110, *a*, and 95, *a*, *b*), Presl and others have considered the curious and beautiful plants of which this tribe is composed as constituting a totally distinct order; but they are so closely connected with *Davallia* by means of *Prosaptia* and *Loxsoma*, and with *Thyrsopteris* by *Trichomanes pluma* and others, that, as it appears to me, there is little doubt about the matter; and if the distinction of oblique and vertical rings (*Helicogyratæ* and *Cathetogyratæ*, Presl) is to be kept up, they must be placed in the same section with *Gleichenia* and *Cyathea*. The coriaceous frond of *Loxsoma*, accompanied by the columella and oblique ring of *Trichomanes*, as evidently removes any uncertainty which might arise from the structure of the leaves.* *Hyme-*

* The frond is not equally reticulate in all the species. In the section *Hymenostachys* of *Trichomanes*, a section in which the veinlets anastomose, the structure approximates that of ferns with a close reticulate venation. In *Trichomanes reniforme* a transverse section shows two

nophyllum is distinguished from *Trichomanes* by its short columella and two-valved indusium, while that of *Trichomanes* is cupshaped, and the columella exserted. In such species as *T. elegans* the cup seems to be entirely a development of the tip of the costa, and this is probably the case generally in the genus *Trichomanes*. Most of the species are tropical, but a few are found in most parts of the world. From their filmy nature, they delight in a moist atmosphere, and some require constant moisture, as the spray of waterfalls, &c. *Loxsoma* is confined to the northern parts of New Zealand, and has the habit of *Davallia*. About a fifth of the New Zealand ferns belong to this division.

17. CYATHEACEÆ, *Kze.*, *Presl.*

Sporangia pedicellate, suborbicular, or obovate, lenticulari-compressed, surrounded by a complete or incomplete ring, bursting laterally. Arboreous, seldom herbaceous.

622. This tribe contains many of the finest forms, distinguished by their arboreous habit, which makes them and similar ferns, some fossil species excepted, the noblest representatives of the Cryptogamic Flora. They are, for the most part, tropical, but yet, like so many others of the finest Cryptogams, they are found in colder climates, provided the temperature is tolerably equable, as in New Zealand and other southern isles. There are species, also, at the Cape, and amongst the Himalayas. Presl remarks that the genera of *Cyatheaceæ* represent the tribes of *Cathetogyratæ*. *Cyathea* and *Cnemidaria** answer to *Paranemaceæ; Matonia*† to *Aspidiaceæ; Hemitelia* to *Aspleniaceæ; Trichopteris, Metaxya*, and *Alsophila*, to *Polypodiaceæ*. Most of them possess a cupshaped indu-

distinct layers of cells. The walls of the contiguous cells are sometimes perfectly confluent, as the cells of the leaves of many mosses and *Jungermanniæ;* but, on the other hand, the line of demarcation is often perfectly distinct. The notion, therefore, that the reticulations arise from anastomosing veinlets is altogether wrong. See Presl, Hymenophyllacées, 1843. Aus den Abhandlungen der Kön. Böhem. Gesells. (v. Folge, Band 3.)

* *Disphenia* is merely a *Cyathea*.

† Now associated with them on account of its superior, not inferior, indusium.

sium ; but this is sometimes entirely wanting, and the sporangia are produced upon a distinct hairy receptacle. *Cyathea* has free veins or veinlets, numerous sporangia, on a raised or club-shaped receptacle, surrounded by a spherical indusium, bursting above or below, and forming a cup round the sorus. In *Schizocœna* the sori are seated on the middle of the veins or veinlets, and the indusium has six lobes, like little petals, surrounding a globose receptacle. In *Hemitelia*, united with *Cnemidaria* by Smith, the lower pair of veinlets anastomose, and the indusium is a mere scale, which leads to the Polypodiaceous genera, in which the place of the indusium is sometimes supplied by hairs or scales. *Alsophila*, *Gymnosphæra*, and *Trichopteris*, differ more in habit than in technical characters. In *Alsophila* the receptacle is mostly hairy, the leaves are decompound, and the stipe often prickly. In *Gymnosphæra* the fronds are bipinnate and sometimes prickly, and the sori quite naked, with the sporangia on a subcylindrical receptacle. In *Trichopteris* the receptacle is oblong, hairy, and the sori laterally confluent, so as to form transverse linear heaps of sporangia. In this, also, the leaves are bipinnate, and the habit different from *Alsophila*. In *Metaxya* the fronds are simply pinnate. Each fertile vein bears several sori, a circumstance quite peculiar to the genus. This differs, moreover, in its spores not being triangular. There is a peculiarity about *Alsophila capensis* which deserves notice. On the lower part of the stipes, and especially that part which joins the caudex, abortive pinnæ are formed, reduced almost to the rachis, and resembling so closely some *Hymenophyllum* or *Trichomanes*, that Kaulfuss has described them with a note of doubt under the name of *Trichomanes cormophyllum*.* In the plant as cultivated at Kew their identity with the pinnæ is evident, as pinnæ of the normal form are often intermixed with others consisting of a rigid costa and narrow hyaline border. The delicate and beautiful fronds of *Cyathea Smithii* are with much good taste used by the New Zealanders to adorn their meeting-houses.

* See Hook. Sp. Fil., vol. i., p. 37. It is to be observed that the structure of the altered frond is quite unlike that of *Trichomanes*.

18. Gleicheniaceæ, *Kze.*

Sporangia sessile or subsessile, globose, subglobose, or trigonal, surrounded by a complete ring; bursting longitudinally. Rhizoma creeping or climbing.

623. The rampant, mostly divided, rhizoma and habit, rather than any very definite characters, separate this little tribe from the arboreous *Cyatheaceæ.* In all, the sporangia are few in number, and disposed in a radiating manner, so that the narrow end is internal They are often seated in a little cavity, and are highly deciduous. The fronds are generally forked or trifid, the third or middle division being supplied sometimes by a little bulblike body. *Platyzoma* has, however, simple fronds, by which character it is principally distinguished. *Gleichenia* has pinnate or forked free veins and veinlets, with apical (*Calymella,* Presl) or immersed superficial sori. *Mertensia* differs in its coarse habit and medial sori, with more evident venation. *Sticherus* differs in its biserial sori. Presl describes the venation as reticulate, but this is denied by Smith. All are tropical or subtropical, with the exception of such as affect the southern islands. *Gleichenia* has four species in New Zealand.

II. Ophioglossaceæ, *Lindl., Hook., &c.*

Ophioglosseæ, *R. B.*

Fronds entire or divided, straight in æstivation; fertile fronds reduced to a linear strapshaped process, the edge of which produces a single row of connate bivalvate sporangia.

624. The æstivation of these plants is so different from that of ferns, and the sporangia so unlike those of *Marattiaceæ,* which can alone be compared with them, that in the absence of all information as to the development of the spores, I cannot but consider them as a distinct natural order. The sporangia, in fact, are nothing more than mere sacs formed in the edge of the fertile frond, and resemble rather those of Lycopods than ferns. The order consists of four good genera, *Ophioglossum, Botrychium, Helminthostachys,* and *Rhizoglossum.* The first has sometimes reticulate nervation, sometimes the fronds are nearly nerveless. The greater part of the supposed species

are reducible with certainty to *O. vulgatum*, which is distributed through almost every part of the globe. In some cases several spikes are produced instead of one. Sometimes, however, the frond is dichotomous, as in a species from Malacca in the Hookerian Herbarium, indications of division having previously occurred in *O. pendulum*, and sometimes it is digitate, as in *O. palmatum*, a species from Bourbon and South America, which has been considered a genus under the name of *Cheiroglossum*. It has, however, no more right to be separated than *Schizæa dichotoma* from *S. flabellum*. This species is remarkable for numerous marginal spikes of

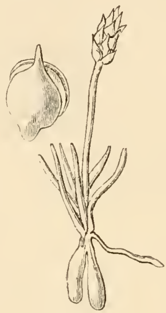

Fig 118.

Phylloglossum Drummondii, natural size, together with one of the bractes, with its sporangium magnified. From a New Zealand specimen given to me by Dr. Hooker.

sporangia arising from some of the transformed lobes, for its stem sometimes assuming at the base the scarlet tint which occurs in Lycopods, for its fernlike rhizoma, and its growing on the trunks of trees. *Botrychium* has divided fronds, and the fruit, consisting of globose sporangia, opening transversely, is produced on spikes springing from the base of the frond, or occasionally at the same time on some of the pinnules. *B. Lunaria* is found in Tasmania, and the New Zealand species is a native of Virginia and of many other countries, but of no part of Europe except Norway, from whence there are specimens in Hook. Herb., and from no part of Asia north of the Himalayas. *Helminthostachys* is similar to *Botrychium* in habit, and has whorls of sporangia which open vertically, surmounted by a crested appendage. It is a native of Ceylon. *Botrychium virginicum* is used as a pot-herb in New Zealand, as is *Helminthostachys* in the Moluccas, and the *Adder's tongue* in some parts of Europe. They are considered as vulneraries, and for that purpose the fronds are boiled in fresh lard. Their virtues are probably only imaginary. Adder's tongue ointment has been much used within my own knowledge for dressing open wounds. The roots are often thick and bulblike, and a new plant comes up every year from the same root, as in terrestrial Orchideæ. Sheep are so fond of *B. lunaria* that it is difficult to get specimens where they have access. These plants are plainly connected with Club-mosses by *Rhizoglossum*, a Cape genus which has precisely the habit of *Phylloglossum* (Fig. 118), consisting of a few subulate leaves and a pedunculate spike of sporangia. *Ophioglossum* varies almost infinitely in size, and in the greater or less elongation of the frond.

III. Equisetaceæ, *D. C.*

Stems branched, articulated, hollow; branches whorled, destitute of anything in the shape of leaves, except the fimbriated sheaths which surround the base of each articulation. Sporangia dependent from the peltate scales of little strobili. Spores surrounded by a membrane splitting spirally into two bands, attached by their centre, and clavate at either end. Archegonia and spermatogonia on the prothallus.

625. The peculiar habit of these plants, resembling that of *Ephedra* and *Casuarina*, at once distinguishes them from all other Cryptogams. They are commonly known by the name of Horsetails, and are amongst our commonest weeds in ploughed fields and marshy spots, in woods, or on the banks of rivers, and sometimes they are found in loose sand, which they tend to bind together by their delicate rootlets.

626. The spores germinate like those of ferns, and produce a prothallus which differs only in its irregular fasciculate aspect

from the reniform Marchantioid expansion of the young plants of that important order. As in ferns, archegonia and spermatogonia are formed upon the prothallus, and the spermatozoids, as in that order, are fringed with abundant cilia. The archegonia give rise equally to the perfect plant, which throws out a rhizoma from which new shoots are produced. The fruit is a little strobilus, terminating the stem or main branches, and consists of peltate scales, supporting a whorl of sporangia, arranged vertically round the short stem, with their base attached to the scale and the upper end free. The walls are composed of beautifully spiral tissue, and the spores arise by cell-division, each spore being covered with a separable membrane, which ultimately splits in a spiral direction, so as to form two bands with clavate apices, which are attached by the middle, so as to look like four stamens. The structure of the rhizoma is very different from that of ferns. In an early stage it consists of a central column of cellular tissue, sending off about eight radiating plates, which connect it with an external cylinder of the same tissue, and opposite to each of which there is in the central column a vascular bundle, consisting of annular vessels passing into spiral. At a later period tissue grows from the walls into the cavities in such wise that they are more or less perfectly obliterated. More abundant cavities exist in the fruit-bearing stems, with various modifications of the component tissue. Annular vessels, however, predominate, as scalariform vessels do in ferns. The cells of the sporangia are remarkable for the beautifully developed spiral formed by their inner coat. The cuticle is furnished with stomates.

627. The affinities of these plants are quite clear since the discovery of the extreme similarity of the mode of development with that of ferns. The archegonia and spermatogonia, with their spermatozoids, are, in fact, almost identical. The resemblance to *Marchantiaceæ* in the fruit is striking, but this is rather one of analogy than of affinity, as the results of impregnation are so different. In *Marchantiaceæ* the archegonia produce merely a sporangium, in *Equisetaceæ* a new plant. The resemblance between these plants, again, and such Phænogams as *Ephedra* and *Casuarina* is very striking, but it is,

after all, merely analogical. The superior development of the vascular tissue indicates a higher type than that of ferns; and if the nobler forms of these are objected, we have but to point to extinct *Equisetaceæ.*

628. Almost the only especial use to which these plants are put by man is that of polishing, which they effect in consequence of the minute crystals of silex which are found in their cuticle. Brewster has shown that the flinty particles are arranged in lines parallel to the axis of the stem, and that each possesses a regular axis of double refraction. Horsetails have been supposed to possess medical properties. *E. arvense,* for example, is said to be astringent and diuretic.

629. *Equiseta* are found in most parts of the world, but there are none in Australia or New Zealand. The tropics have their species as well as more temperate climes. A few of the species, as *E. variegatum, sylvaticum,* &c., have a very wide distribution. The former occurs as far north as Iceland; it is found also in Quito, Bourbon, and Uitenhage, while *E. sylvaticum* is found from the Arctic regions of North America to Simla. *E. giganteum,* a Brazilian species, attains several feet in height, with a stout stem, three quarters of an inch in diameter. One species, on the contrary, *E. debile,* is so weak that it requires the support of low bushes, up which it may be said to climb, and Welwitsch describes *E. elongatum* as climbing up *Agave Americana* at Lisbon.

630. The largest *Equisetum* of the present day is not to be compared with the noble representatives, as *Calamites,* which occur in the Coal Measures and the New Red Sandstone. True *Equiseta* also occur in a fossil state. The recent species vary greatly in size, branching, and the length of their internodes. *E. arvense* produces tubers on the creeping rhizoma.

IV. Marsileaceæ, *R. B.*

Rhizocarpeæ, *Batsch., Ag.* Rhizospermæ, *Roth., D. C.* Hydropterides, *Willd.*

Æstivation straight or circinate, leaves various or reduced to a petiole; receptacles* more or less radicular, formed from

* These receptacles are called in the tabular view of the acrogenous

a metamorphosed leaf or footstalk divided by septa, or unilocular; antheridia in the same secondary receptacle with the monosporous sporangia, or in a distinct sac; prothallus confluent with the spore, not forming a distinct expansion.

631. The plants of which this curious natural order is composed are all aquatic, and are so diversified in structure, though they have several characters in common, that they may be, and indeed have been, referred to two distinct natural orders. *Marsilea* and *Pilularia*, for instance, are associated in one group, *Salvinia* and *Azolla* in another. *Isoetes*, though

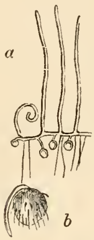

Fig. 119.

a. Pilularia minuta, Durieu, natural size, from a cultivated specimen.

b. Receptacle of ditto, slightly magnified.

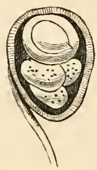

Fig. 120.

Receptacle of *P. minuta*, divided vertically, so as to show a sporangium and three antheridia. From Expl. Scient. de l'Algérie.

slightly anomalous, is clearly a Lycopod. The four first agree in having receptacles formed, evidently, from a metamorphosed leaf or leafstalk, while in *Isoetes* the fruit is lodged in the axil of the leaf, and probably arises, not from the leaf itself, but from an axillary bud. Its spores and male organs are almost identical with those of *Lycopodia.*

632. The affinities of these plants with other Filicals are at first far from evident, the structure of the fruit is so very

Cryptogams sporangia, according to the commonly received nomenclature. But as homologous organs should have the same name, the word sporangia is here used for the ultimate common envelope of the spores.

different. We can, indeed, point rather to analogies than affinities. Where the limb of the leaf is expanded and firm, there is a reticulate venation like that of *Ophioglossum. Azolla* resembles *Jungermanniæ* in habit and the antheridia, or perhaps more properly the receptacles of the antheridia, as those of *Salvinia* also, have the same external form. In the perfection of their spiral vessels, which are sometimes capable of being unrolled, they resemble *Equisetaceæ*. *Azolla* is extra European, and is found in hot countries and the temperate regions of the south, and also in North America. The other genera all occur in Europe, but are not confined to it, or in general to temperate regions.

633. As the structure of these plants is so peculiar I must give a few details of each genus separately. *Pilularia* (Fig. 119) has a filiform creeping rhizoma, which from space to space gives off erect and, at first, circinate filiform leaves or footstalks, whichever may be their proper name. From the same thread-like rhizoma, short processes are given off, each of which produces a pillshaped receptacle, embraced by the stalk, and evidently formed either by the tip of the metamorphosed footstalk, or from the limb of the leaf, which is not developed in other cases. This receptacle (Fig. 120) is divided by septa into two or four cells, each of which has a sort of placenta, to which the obovate antheridia and sporangia are attached. Each sporangium contains only a single spore. This has a firm outer coat, which tapers to a point, leaving a little cavity at the top of the nucleus. This cavity, according to Hofmeister, is gradually filled up with cellular tissue, constituting a conical prothallus confluent with the nucleus. A single archegonium is formed in the centre, the orifice of which corresponds with the apex of the prothallus. The antheridia contain a large number of grains, from which the spermatozoids are ultimately developed. The spermatozoids are long, spiral, and very delicate. The embryo formed in the archegonium germinates after the fashion of a monocotyledon, sending off a frond in one direction, and a root opposite to it. *Pilularia* occurs in the north of Africa and Tasmania, as well as in Europe. The species, which are very few in number, are mere botanical curiosities.

634. *Marsilea* has very much the habit of *Pilularia*, but the leaf-stalks bear several cuneiform lobes, which make low starved specimens where the lobes are reduced to three, and the water has dried up in which they first took their growth, look very like some procumbent *Leguminad*, especially as the hard receptacles, to the outward eye, resemble seedpods. These receptacles are evidently modifications of the leaves, but are more complicated than those of *Pilularia*. The bivalved receptacle at length bursts, and a long mucilaginous cord protrudes, attached to the receptacle, where its lobes diverge from the peduncle. This bears on either side obovate receptacles of the second order, which in an earlier state of growth were connected with the veins of the primary receptacle. Each partial receptacle is ovate, and, as in *Pilularia*, bears a sort of placenta, which is beset on one side with sporangia (Fig. 121, 122), on the other with antheridia. The sporangia, as before, contain only a single spore, which consists of a nucleus and cellular integument. The germination closely

Fig. 121.

Part of the mucilaginous cord of *Marsilea pubescens*, with a receptacle of the second order, containing antheridia and sporangia. From the Flora of Algiers.

Fig. 122.

Sporangium of the same, magnified.

resembles that of *Pilularia*. In both the stem contains a circle of cavities formed by dissepiments, radiating from a central mass of cellular and vascular tissue, with unrollable spiral threads. *Marsileæ* are aquatic plants, but are not always submerged. *Marsilea quadrifolia* is very widely diffused both in tropical and temperate, but not in cold, countries. The

South of Europe and North Africa, Oregon, Madras, New Holland, and Brazil, possess representatives of the genus. *M. polycarpa* is remarkable for having numerous receptacles half-way up the leaf-stalk. The species are of no ascertained utility. The fossil *Sphenophyllum* probably belongs to *Equisetaceæ*.*

635. *Salvinia* agrees with the two former genera in the character of the rhizoma and radical fruit. The fronds, however, have a fern-like aspect, but they are remarkable for having warts radiating from the costa, and crowned with a little tuft of jointed threads. The veins are visible below, and are reticulated. The fruit consists of globose fluted sacs, containing a little central columella, to which are attached, in separate sacs, the antheridia and sporangia. The antheridia are globose and pedunculate, resembling strongly those of a *Jungermannia;* the cellular-walled sporangia are monosporous. The spores germinate after the fashion of *Marsilea* and *Pilularia;* but the antheridia are like those of *Azolla.* The stem has cavities, as in those genera, with a central bundle of vessels. It is probable that all the supposed species are reducible to one, and if so it occurs in the warmer parts of Europe, and in the tropics of Asia and South America. At any rate, *S. natans* is found on the Niger, in the East Indies, Brazil, and Quito.

636. *Azolla* agrees with *Salvinia,* to a certain extent, in the antheridia, but has the habit of a floating *Jungermannia.* The antheridia are contained in a common sac, as in *Salvinia,* and have a similar form to those of that genus; but they contain four or more masses, analogous to the pollen masses of Asclepiads, fringed with barbed pellucid threads (Fig. 123), first, I believe, observed by Mettenius, or furnished on one side with irregular root-shaped appendages. The sporangia hang down from the frond, consisting, at their base, of a variable number of lobes or appendages. Beyond this is a sort of ring, and then the naked spore connected by a villous thread with the parent plant. The spore in itself resembles those described above, and, probably, germinates in the same manner. This point, however, is at present obscure. The

* See Ettingshausen Steinkohlen, Flora von Radnitz. Wien, 1855.

receptacle of the sporangia is sometimes obscure or obsolete ; sometimes, however, it is decidedly present. The species vary in the form of the leaves, the number of the appendages, and

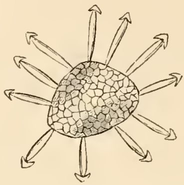

Fig. 123.

Mass from the Antheridium of *Azolla rubra*. From a specimen given to me by Dr. Hooker.

the minute details of the antheridia and their contents They are mostly tropical and sub-tropical, extending, however, to New Zealand and Tasmania in the south, and to New York and Ohio in the north.

V. Lycopodiaceæ, *D. C.*

Lycopodineæ, *Swartz*, &c.

Sporangia bi-tri-valvular, unilocular, axillary, very rarely multilocular, containing large spherico-tetrahedral spores ; antheridia closely resembling the sporangia, filled with minute free bodies, resembling the spores in form which ultimately produce spermatozoids.

637. The greater part of the Club-mosses are distinguished, in consequence of their linear leaves, by a habit resembling that of Conifers ; and in many details of the fruit, there is a very close analogy between the two orders, though, as I hope has been satisfactorily proved above, there is no real affinity between them. As, however, amongst Conifers there are species with broad leaves, departing greatly from mere normal forms, so in these Cryptogams there are broad-leaved *Lycopodia ;* while in *Tmesipteris*, the coniferous habit has almost vanished. *Phylloglossum* (Fig. 118), though a true Lycopod,

as to the details of the spicate fruit, departs greatly in habit, being, as to other points, almost a precise repetition of the Ophioglossoid *Rhizoglossum;* while *Isoetes* connects these plants evidently with *Marsileaceæ.*

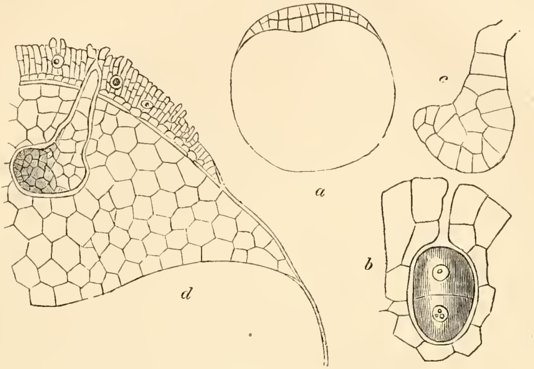

Fig. 124.

a. Spore of *Selaginella helvetica*, shortly after it has been sowed, divided vertically.

b. Archegonium of *Selaginella denticulata*, after impregnation.

c. Young embryo of ditto.

d. Prothallus of ditto, with archegonia, one of which has produced an embryo.

Fig. 125.

Mouth of archegonium of *Selaginella denticulata*, seen from above and laterally.

Fig. 126.

Embryo of *Selaginella Martensi.*

These three figures, which are all more or less magnified, are from Hofmeister.

638. The germination of the spores, and the evolution of the sporelike bodies of the antheridia in Lycopods, do not take place till some months after they are committed to the ground. The germination of the spores (Fig. 124) consists in the formation of a prothallus by cell-division, adherent to and confluent with the spores, as in *Marsileaceæ*, or penetrating their cavity, without the protrusion of threads as in Ferns or Mosses. This cellular matter may occupy only a small portion of the cavity (Fig. 124, *d*) of the spore, or it may fill it entirely. Archegonia soon appear in the prothallus, generally in greater number than in *Marsileaceæ*, and the embryonic mass is formed from a cell at the base of the archegonium (Fig. 124, *b*). The embryo is usually situated transversely, with an evident opposition of the ascending and descending points of vegetation, and two leaves are ultimately formed (Fig. 126), which have a close resemblance to Cotyledons. The stems, when developed, consist of a mass of thick walled, often dotted, cells, inclosing one or many fascicles of scalariform tissue, which send off branches to every leaf and bud. The scalariform tissue is accompanied by fine elongated, or sometimes coarser, cells, which are occasionally distinctly reticulated, as in *Lycopodium Selago.* There is no crossing of fascicles as in Endogens, and there are no medullary rays. The stem, in fact, approximates closely to that of ferns, to which these plants are nearly allied; but the fascicles of vascular tissue are confined to the centre. Their relations to Conifers, though indicated by many curious resemblances, are strictly analogical. Though the pollen grains of Conifers undergo curious changes after they are separated from the anthers, these changes do not result in the formation of spermatozoids or anything homologous; and though there is much resemblance between the formation of the archegonia and embryonic body in Lycopods, and that of the corpuscles and embryos in Conifers, the origination of the spores from mother cells in the former is so distinct from that of the ovules in Conifers that homology is out of the question, and we have, therefore, mere analogies to build upon, which, however curious, indicate no affinity; a fact confirmed by the great

difference of the stems. Indeed, Lycopods, though attaining so great perfection, and on the whole presenting the highest cryptogamic types, are, as regards the tissues, scarcely so near to Phænogams as *Equisetaceæ* and *Marsileaceæ*, though the former present a lower type of fruit, notwithstanding the great development of the stems in the fossil genera, while the latter, with a form of fruit and tissues of equal if not superior dignity, bear the same relation as regards the stem to the higher Lycopods, that degraded aquatic Phœnogams do to more highly organized terrestrial plants of the same natural order. *Isoetes*, indeed, with a degraded habit, has tissues as highly organized as those of *Equisetum* or *Marsileaceæ*.

639. *Isoetes* has a globose rhizoma sending down many strong roots from the base and deeply umbilicate above, in such wise that the base of the youngest frond is lower than that of the older. The fruit is incorporated with the base of the leaf, but, morphologically speaking, is axillary, like the sporangia of *Lycopodium*. Above the fruit is a small appendage resembling the ligule of a grass. The sporangium when divided exhibits a number of threads, to which the spores are attached. The latter are globoso-tetrahedric and naked, like those of *Lycopodium*. The fruit, therefore, bears a manifest relation both to that of *Marsileaceæ* and *Lycopodiaceæ;* the former it resembles in the approach to a multilocular receptacle, like that of *Marsilea;* the latter in the axillary mode of growth and the naked globoso-tetrahedric spores. The leaves possess stomates, and there are annular vessels in the roots and rhizoma, in which it resembles *Equisetum*. The spermatozoids are, according to Hofmeister,* like those of *Equiseta* and Ferns. The germination is like that of *Lycopodium*. On the whole, therefore, notwithstanding the difference in tissue, it should seem that it is a true Lycopod. *Isoetes* occurs in many parts of Europe, the north of Africa and America, Brazil, Australia, Hindostan, &c. There are several well-characterised species, some of which are beautifully illustrated in the Flora of Algeria. All the species are

* Beiträge zur Kenntniss der Gefässcryptogamen. W. Hofmeister, Leipzig, 1852.

strictly aquatic, and often grow in deep water, where they are never uucovered in the driest seasons. In *Phylloglossum* (Fig. 118) the fronds are subulate or cylindrical as in *Isoetes*, but the rhizoma is reduced to a mere point, while the roots are dilated into tubers like those of *Botrychium* or *Rhizoglossum*, and the fruit is borne in the axils of the bractes of a pedunculate spike. If there was some doubt as to the affinities of *Isoetes*, there is none here, as the plant is a complete Lycopod except in foliage. It occurs in Australia, New Zealand, and Tasmania, in peaty soil.

640. *Selaginella* is distinguished by its flat mosslike habit, and the evident differentiation of the fruit, the sporangia consisting of bi-trivalved sacs containing a few large spores, the antheridia of subglobose sacs filled with orange or scarlet minute bodies which ultimately produce the spermatozoids. Both are sometimes contained in the same axil, but they are sometimes separate. The leaves are usually of different sizes, calling to mind such genera as *Hypopterygium* (Fig. 99, *d*) and *Cyathophorum* (Fig. 109). The rhizoma is generally creeping, but sometimes tall erect stems tower up, having feathery branches or fronds clad with leaves. In *Lycopodium* the fruit is not at first sight so evidently distinguishable into male and female, though in essentials it accords exactly with *Selaginella*. The plants, moreover, though frequently trailing, are more or less cylindrical, and sometimes rise into a thickish trunk. The leaves are often subulate, but they are sometimes flat, as in *Selaginella*, or form rigid scales. The habit, in fact, assumed by the numerous species is extremely various. *Tmesipteris* is remarkable for its pendulous habit, very broad leaves, and vertically bursting sporangia, which spring from the axis of the stipitate didymous fertile pinnæ. The leaves or pinnæ are sometimes acuminate, sometimes truncate; but both characters exist together frequently in the same specimen. *Psilotum* has triquetrous stems, with trilocular sporangia, thus departing from the normal character, as also in the small ill-developed setiform leaves. The minute bodies contained in them burst when placed in water, and emit a cloud of microscopic particles.

641. Though many species of *Lycopodium* are found in tropical and subtropical countries, it is far less addicted to warm localities than *Selaginella*, which does not occur at all in New Zealand or Great Britain, though both countries contain many species of *Lycopodium*. *Lycopodium alpinum* and *Selago* are fond of a moist cold climate, and it is only in high latitudes that they appear in the plains, while on the contrary *L. inundatum* forms large patches in the marshes of the south of England. New Zealand has far more species of *Lycopodium* than Great Britain, and several of them are amongst the noblest of the genus, and may be regarded as tropical forms. A curious instance of the appearance of a tropical species in temperate latitudes is afforded by *L. cernuum*, a species very widely diffused in the tropics. It occurs about the warm springs of the Azores in Terceira and St. Michael's,* in spots exposed to the sun, and again in the southern island of St. Paul, a fact which has its parallel in the occurrence of a tropical *Pteris* under similar circumstances in a small island in the Mediterranean. *Tmesipteris* is widely diffused in the southern hemisphere, extending to California, and often grows on the trunks of tree ferns; and *Psilotum* extends through most of the tropics, and reaches the Southern United States through Brazil and Central America.

642. The degree to which some of the species vary is admirably illustrated in Dr. Hooker's Memoir. Figures are given of *Lycopodium densum* under different forms which grow intermixed in New Zealand. One is densely fastigiate, with broadish ovato-lanceolate leaves, closely appressed to the stem; in the second the habit is diffuse, the leaves narrow, far more elongated, and not at all appressed, so that the plant looks squarrose; but even in this form the leaves are very different in different parts of the stem; in the third form the branches are all slender and clothed with narrow appressed leaves, which are sometimes imbricated, sometimes disposed in whorls. The student, therefore, must be prepared for patient

* The ticket which accompanies the specimens in the Hookerian Herbarium states that the temperature of the water was 114°, the air at the same time being at 65°.

investigation before he determines what are and what are not good species.

643. *Lycopodium catharticum* has been celebrated as a strong cathartic. Dr. Hooker has tried the dry plant and found it inert, but so many drugs lose their virtues when kept beyond a few months that we need not be surprised at the different reports respecting this *Lycopodium*. Even our own *L. Selago* has sometimes been used as a cathartic, and other species have been employed in medicine. The inflammable nature of the spores of *L. clavatum* has caused them to be used on the stage to form artificial lightning. They are also employed like liquorice powder to keep pills from adhering to each other. If the fingers are rubbed with them, and immersed in water, the fluid is so strongly repelled that it will not wet the skin. Clubmosses are used in dyeing, to produce a blue tint. They are sometimes of a deep red, a colour which is often partially assumed by the tissues, and may possibly have other virtues as dye-stuffs.

644. *Selaginella convoluta*, like the rose of Jericho, has the property of contracting into a ball when dry, and expanding when moist. A singular phenomenon has been observed in a species of *Selaginella* (*S. mutabilis*) cultivated at Kew. In the morning the fronds are green, but as the day advances they become pale, recovering gradually their colour by the following day. Dr. Hooker has observed that in their pale condition the endochrome of the cells of the leaves is contracted into a little pellet. I have had no opportunity of examining the matter myself, but I found in winter the paler parts of the leaves to exhibit a contracted condition of the endochrome, like that observed by Dr. Hooker.

645. It remains only to say a few words respecting the fossil forms presented by species belonging to this natural order. These are amongst the noblest specimens of vegetation, and well deserve the attention of the botanist. Few points, perhaps, have been more debated than the true affinities of such plants as *Sigillaria*, *Stigmaria*, *Lepidodendron*, &c. If, however, the structure of the stems be considered, and the fruit of *Lepidostrobus* be allowed to belong to *Lepidodendron*,

there can be little doubt that Dr. Hooker is right in considering them highly developed *Lycopodia.* The stem, for example, of *Lepidodendron* consists of a central mass, composed principally of large scalariform vessels, giving off branches, which traverse a mass of thick walled cells to the scars of the leaves; while that of *Sigillaria* has wedges of vascular tissue, interrupted by rays passing from the surrounding cellular tissue to the centre. *Sigillaria*, then, is merely a form allied to *Lepidodendron* approaching still more closely the structure of Phænogams. In *Stigmaria* the bundles arise from ducts seated nearer to the centre than the wedges; in *Sigillaria*, on the contrary, they arise partly from the outer margin or convexity of the wedges, partly from the inner margin or angle of the wedge, the fascicles uniting in front before they enter the leaves. *Stigmaria* has been shown by Dr. Hooker to be merely the roots of *Sigillaria*, and the connection of *Lepidostrobi* with *Lepidodendron* is no less certain. The stems of the latter differ principally from *Lycopodium* in size, and so the cones of the former differ in their greater development, and in the thickness of the scales approaching those of Conifers. The spores of *Lepidostrobus ornatus*, as figured by Dr. Hooker, are spherico-tetrahedral, just like those of *Lycopodium.* Three spores are sometimes formed from the same mother cell adhering by their triangular faces, and sometimes four, so that the Triplosporite* of Brown does not seem to be generically different from *Lepidodendron.* However similar the cones may be to those of Conifers, or however enormous the sporangia in comparison of those of recent Lycopods, it must be remembered that they are sporangia still, and that their contents are spores, often much smaller than in any modern club-mosses. There is much reason to believe that the curious fruits described by Dr. Hooker in the Proceedings of the Zoological Society, 1855, p. 562, 566, are closely allied, though possibly belonging to a distinct natural order. The fructifying bodies seem clearly to be spores, but they are very different in the two genera; in the one approaching those of ferns, in the

* Linn. Tr., vol. 20, p. 469.

other those of mosses, though the nature of the vascular tissue, the sporesacs, and other points seem to indicate their mutual affinity. *Chorionopteris*, referred by Corda to ferns, and supposed to be allied to *Gleichenia*, is another anomalous Cryptogam, whose true affinities can scarcely be determined without better materials.

ADDITIONS.

NOTE, *Page* 4.—The word *Cycads* has inadvertently been substituted for *Zamiads*. The statement is wrong if *Cycad* is compared with *Stangeria*.

Page 89.—Pringsheim has lately published some additional observations on the impregnation of *Œdogonium*, in Monatsbericht der Kön. Ak. der Wissenschaften zu Berlin, 1856. The upper cell of the antheridium produces two elliptic bodies which pass into the cavity of the spore-cell and there effect the impregnation of the spore. The antheridia are first formed within special cells, from which they escape and move about by means of a coronet of cilia, till they fix themselves upon the spore-cells. Dippel has called in question some of Pringsheim's observations in Flora, 1856, No. 31, 32, without, however, at all shaking them. Pringsheim proposes the name of *Androspores* for these bodies, to distinguish them from other *Microgonidia*. See also Cohn on *Sphæroplea annulina*, translated in Ann. d. Sc. Nat., Sept. 1856.

Page 157.—An elaborate paper on *Chytridium* has lately been published by Braun in the Transactions of the Berlin Academy, 1856. Some of the species closely resemble the antheridia of *Œdogonium* and *Bulbochæte*, and as they occur on the fertile cells they require to be carefully distinguished.

Page 168.—Thuret has published some additional facts on the antheridia of Algæ, in Ann. d. Sc. Nat., Jan. 1855. He has found these organs in seventy Rhodosperms.* In *Ecto-*

* These belong to the genera *Porphyra*, *Bangia*, *Callithamnion*, *Griffithsia*, *Halurus*, *Ceramium*, *Furcellaria*, *Gigartina*, *Phyllophora*, *Lomentaria*, *Rhodhymenia*, *Plocamium*, *Helminthocladia*, *Helminthora*,

carpus Mertensii (*Tilopteris Mertensii,* Kütz) propagation does not take place as in true *Ectocarpi* by zoospores, but by large inactive spores. The antheridia are similarly situated with the spores, and produce spermatozoids like those of *Fuci.* The spores, however, like those of *Cutleria,* germinate without the access of the spermatozoids. In *Dictyota, Dictyopteris, Taonia,* and *Padina,* he finds inactive spores; while *Asperoccus* and its allies are propagated by zoospores. He describes and figures the antheridia of *Dictyota dichotoma,* and shows the necessity of considerable reformation in the classification of the Melanosperms in consequence of the diversity of the reproductive organs.

Page 319.—Tulasne has stated his opinion, in his memoir on *Uredineæ,* Ann. d. Sc. Nat., sér. 4, vol. 2, p. 77, that the greater part of the *Uredines* are merely stylospores of *Puccinia, Triphragmium,* &c. His account of the genus *Cronartium,* which grows on the leaves of *Pæonia, Asclepias Vincetoxicum,* &c., is curious. It consists of a little cellular sac, perforated by a column arising from its centre. This is surrounded at the base by stylospores, which are capable of germination. The cells of the column itself also germinate and produce minute globose spores, which in their turn germinate. The column, therefore, consists of an aggregation of spores germinating in situ, and not, as has commonly been supposed, of a peridium inclosing spores.

Page 467.—A remarkable instance of anomaly in the geographical distribution of mosses is afforded by the species which

Nemalion, Hypnea, Cruoria, Peyssonelia, Melobesia, Gracilaria, Nitophyllum, Delesseria, Spermothamnion (Callithamnion Turneri), *Bornetia* (Griffithsia secundiflora), *Wrangelia, Chylocladia, Laurencia, Bonnemaisonia, Alsidium, Rhodomela,* and *Polysiphonia.* Derbès and Solier have observed them, in addition, in *Rytiphlæa.* It will be observed that *Porphyra* and *Bangia* are placed amongst Rhodosperms by Thuret, which they resemble in the nature of their antheridia. Still more recently Derbes has detected antheridia in a new genus, *Ricardia,* allied to *Dumontia,* and in *Taonia,* after the fashion of those of *Dictyota.* (Ann. d. Sc. Nat., Oct. 1856.)

affect the erratic blocks scattered over the plains of Germany. Such species as *Andræa Rothii*, *Catascopium nigritum*, *Grimmia trichophylla*, *G. leucophæa*, &c., are not species of so low an altitude. The geological bearings of this anomaly are obvious. See Itzigsohn in Bot. Zeit., 1853, p. 601, and 1856, p. 913.

Page 547.—It ought to have been mentioned that the structure of the stem in *Botrychium* is more nearly that of Ferns than Lycopods. Two or more bundles of scalariform tissue are disposed round a central mass of parenchym. In *Ophioglossum vulgatum* the central tissue is wanting, and about five vascular bundles are seated on the walls of the cavity.

Page 558.—The vascular bundles are sometimes confined less exclusively to the centre in *Selaginella*. In *S. Philippina*, Spring, besides the ordinary scalariform tissue, I find true spiral vessels, and the bundles inclined to form a circle, and vessels may probably be found passing from spiral into true annular vessels, as in *Equiseta*. The normal characters, however, are not affected by such exceptions.

A LIST

OF

SOME OF THE MOST USEFUL WORKS AND MEMOIRS

RELATING MORE OR LESS TO

CRYPTOGAMIC BOTANY IN GENERAL,

AND ITS SEVERAL BRANCHES.

It is not the intention of the present List to supply anything like a complete catalogue of Works on Cryptogamic Botany, which would require several sheets of letterpress. Pritzel's Catalogue will in great measure afford such information. It has, however, been thought advisable to note a few of the more important sources of information, whether physiological or systematic. A complete catalogue of memoirs is still a desideratum.

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