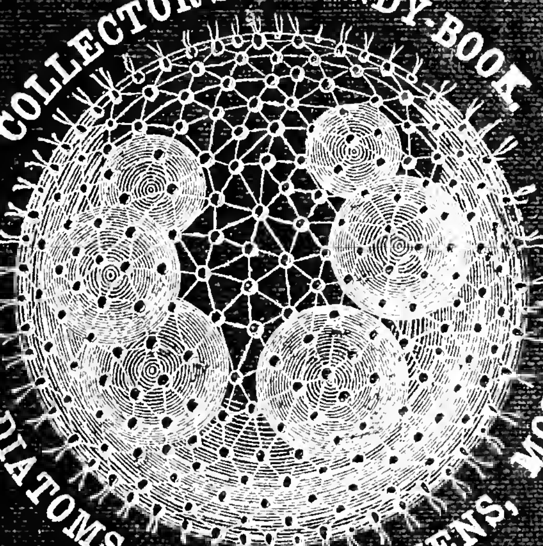
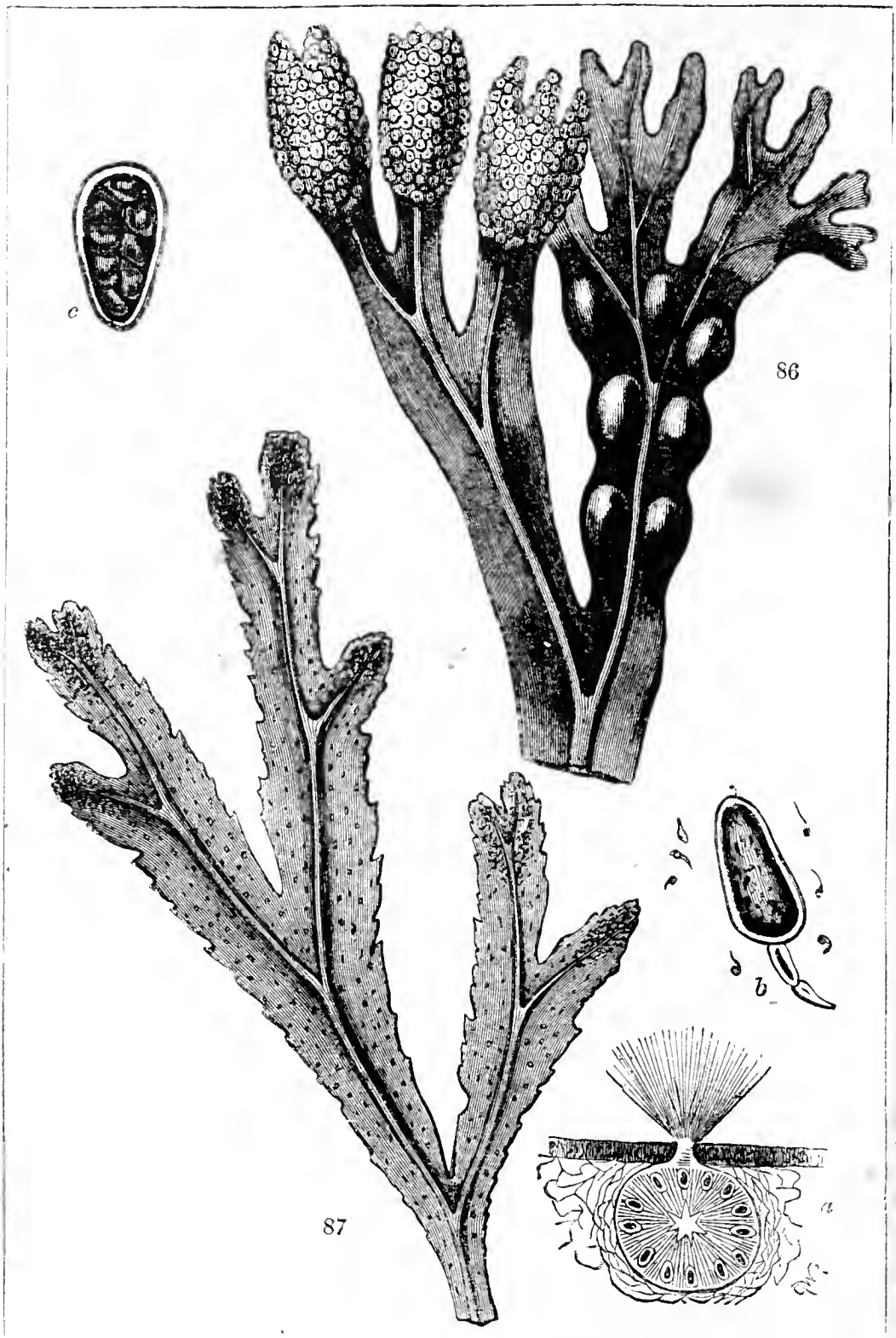
COLLECTOR'S HANDY-BOOK,



ALGÆ, DIATOMS, FUNGI, LICHENS, MOSSES, &c.

Thomas Graham,

May 8, 1921



86. Fucus vesiculosus.
87. Fucus serratus *a*. fertile cell ; *b*. zoospores ; *c*. spores.

A Handy-Book to the Collection and Preparation of Freshwater and Marine Algæ, Diatoms, Desmids, Fungi, Lichens, Mosses

And Other of the Lower Cryptogamia

WITH INSTRUCTIONS FOR

The Formation of an Herbarium

BY JOHANN NAVE

TRANSLATED AND EDITED BY

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Fellow of the Royal Microscopical Society

LONDON

ROBERT HARDWICKE, 192 PICCADILLY

1867

These are Thy glorious works, Parent of good,
Almighty, Thine this universal frame,
Thus wondrous fair; Thyself how wondrous then,
Unspeakable! who sitt'st above these heav'ns
To us invisible or dimly seen
In these Thy lowest works; yet these declare
Thy goodness beyond thought, and power divine.

MILTON.

LONDON
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NEW-STREET SQUARE

PREFACE.

Of the convenience and utility of an Herbarium to the Botanist, it is needless to say a word. The first instinct of the student of Natural History is to collect together specimens of the objects to which his attention is directed. Indeed before long he becomes aware of the positive necessity of having by him examples, on which he can readily lay his hand, for reference and comparison. Simple, however, as it appears to be to make an Herbarium, there is no point, respecting which the young naturalist (without experience and without a guide) more frequently violates the most important canons of science. The correct representation of the natural habit of the plant, and the best method of preserving it when found, are the rocks on which the beginner constantly makes shipwreck. Speaking generally, his errors arise from giving either too much or too little attention to the matter. In the first case he looks only to the beauty of the specimen, and its neat appearance in the cabinet. He takes care—too much care, indeed —to lay out the various parts in a manner to please the eye, but without any reference to their natural

position, or true relation to each other. In the other case, he is careless about the preservation of the plant, and neglects the commonest rules, whereby alone it can be saved from speedy destruction. The result, in both cases, is the same. His preparations are untrustworthy and well nigh useless—at any rate, can lay no claim to any scientific value.

The lower Cryptogamia especially, such as the Algæ and Fungi, require a somewhat complicated mode of treatment: so much so, indeed, that many a beginner is frightened from prosecuting his studies, disgusted by the continued failures, which, without a guide to lead him, it was next to impossible for him to escape. And yet so full of beauty and interest are these lowly orders—enchaining the mind and arresting the attention of all, who are deeply engaged in their study, that it seems hard, that any should be debarred from the enjoyment of so much pleasure by mere mechanical difficulties, which, after all, may be easily removed.

As cases of this kind have frequently come under my own observation, I have prepared the following pages with a view to place near the novice in botany an adviser, who may offer him, in a condensed form, some useful suggestions respecting the best methods of collecting and preparing plants for the Herbarium.

I have done this without the intention, or even the idea, of offering to the public anything essentially new, or better than what has been already published;

but because I know how troublesome and difficult it is for the tyro, in the commencement of his studies, to search through numerous works for a description of the method of preparation, which he may chance to need at the time. Here at least I can promise him, that he will find the most important facts contained *in nuce*, to the saving of both his time and patience. And this is the more necessary, because a novice's library is not usually too well stocked with books of reference; and, besides, he is not always in a situation to consult larger and more important works, bearing on the subjects treated of here.

Therefore I launch this little volume into the world, with the earnest wish that its perusal may be of service in lightening the labours and smoothing the path of more than one self-taught botanist.

Joh. Nave.

The reader will observe, that the chapters into which the book is divided, are of very unequal proportions, and that the greatest prominence is given to the Algæ, which occupy quite one-half of the whole work. This is owing to the extraordinary variety of form and habit, which characterises this family, calling for numerous descriptions of methods of preparation which need not to be repeated.

J. N.

CONTENTS.

LIST OF ILLUSTRATIONS.

LIST OF ILLUSTRATIONS IN TEXT.

GUIDE TO COLLECTION.

CHAPTER I.

OF THE ALGÆ GENERALLY.

FEW STUDIES afford more instruction, or are attended with more genuine pleasure, than that of the Algæ. And this is not simply due to the boundless wealth of form which they exhibit, and which astonishes and delights even those who have never given their attention to Natural History. Nor is it merely on account of the inexhaustible materials for observation and comparison which they afford to the botanist. But the main point of interest consists in this, that it is only by a close investigation of the conditions of life existing in the Algæ, that we are enabled to get a true insight into the structure and functions of the higher plants. In fact, it is not too much to say, that vegetable anatomy and physiology, and the theory of the nature, development, and increase of vegetable cells—depend in no slight degree on the close observation of the Algæ; because in them the separate existence of each cell is so clearly seen. Whoever, therefore, would cultivate the study of vegetable anatomy, must first make himself thoroughly acquainted with this particular family.

Materials for observation are always near at hand, for Algæ abound *everywhere*; often, indeed, where the superficial observer would scarcely expect to find even the smallest trace. Wherever water collects in large or small quantities, in a sea or lake, in a river or pond, and equally in the smallest ditch or puddle, or even on the face of a damp wall, there Algæ thrive, and invite the attention of the

collector. It would be a mistake, therefore, to examine only the larger masses of water; for frequently the least important localities afford the largest supply: indeed, certain families (for instance the Scytonemaceæ and Nostochaceæ) would be constantly overlooked, if the lowlier spots were habitually neglected. In the same way a careful survey of a half-dried pool or puddle will often give the richest returns.

The filamentous Algæ (such as the *Confervaceæ*, *Zygnemaceæ*, and *Vaucheriæ*) are generally the first to strike the attention of the collector, partly on account of their mode of growth, in large tufted masses, and partly on account of their bright green colour, so like that of the Phanerogamia.* It is best, therefore, to make our first acquaintance with these, and through them with the more minute members of the order—the Diatomaceæ, Desmidiaceæ, &c., numbers of which are generally to be found adhering to the entangled tufts of their more gigantic relations. The rest may be made out by degrees, as the necessary amount of observation is given to them.

To avoid needless repetitions, we will commence by offering some suggestions which will be found useful in collecting these plants. As a general rule, the collector is strongly advised to give his attention to everything that can possibly be of the nature of an Alga; for, without the microscope, he will often be unable to decide what he has before him. And if he is sometimes vexed at finding that he has carried home some worthless object, he is at least as likely to regret having thrown away from ignorance something of value.

* Many members of the Zygnemaceous family are especially conspicuous, when viewed under the microscope or a good lens, on account of the beautiful manner in which the cell contents are disposed. Instead of forming a simple uniform ground colour, as is usually the case, the chlorophyll, or green matter, is arranged in spirals of exquisite pattern. In a few species the serpentine band is solitary, but, generally speaking, there are from two to four spirals interlacing and crossing each other at regular intervals. Figures 1 to 6, Plate I., will help to illustrate the above remarks.—Ed.

Green and brown excrescences on wood, slimy masses on plants, pieces of wood and stone that have lain long under water, layers of mud of a greenish or rusty brown colour are things not to be passed by. Neither let him neglect to examine such matter as the outflowings from a manufactory, or walls which have been moistened by the vapour issuing from a steam engine; for, in situations of this kind, Algæ are often developed, which may otherwise be looked for in vain except in hot springs. But, above all, the Algologist should never forbear to collect an object under the supposition that he already possesses it. In the first place he cannot be quite sure of this until he has placed it under the microscope. Next to that, on the same batch of specimens which have been collected early in the season, most interesting parasites (as, for instance, Characium and Hydrocytium) will often be found at a later period. Lastly, it is actually necessary to examine certain species at different times of the year, if the development and fructification are to be satisfactorily determined. Let it then be an axiom with the collector of Algæ, to take care to gather always more, rather than less, than he actually needs.

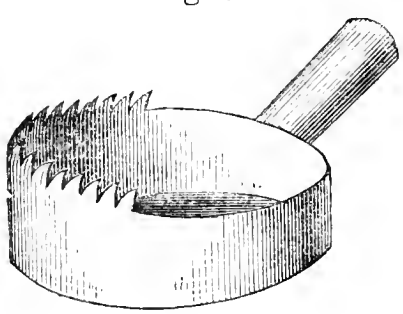
With regard to the fittest season for collecting waterweeds it is sufficient to observe, that they are to be obtained at all periods of the year, not excepting the winter, many of the Diatomaceæ showing themselves to be perfectly indifferent to extreme changes of temperature. At the same time increase takes place most largely in the spring. On the other hand the autumn is the best time for gathering Desmidiaceæ. In fact, the periods of vegetation vary considerably. The species of Ulothrix, for instance, occur only during the early months of summer, and then vanish almost entirely. Again it is requisite to observe, whether Algæ are constant in any given spot, or whether (as is often the case) they appear there for a time only, and then disappear altogether. Thus I have noticed Hildenbrandtia rosea, Œdogonium fonticola, and Batrachospermum moniliforme developing themselves,

season after season, in the same situation; while other species, which were at one time just as abundant, have entirely vanished, without any apparent reason. Take, for example, Hydrodictyon utriculatum. It is quite astonishing in what abundance this species will suddenly fill some pond or ditch, at times almost obstructing the flow of water, only to disappear again after a while without leaving a trace behind. So that, if a person is anxious to gather a large number of specimens (for the sake, say, of making exchanges), he must be careful to do so while he has the opportunity, and not leave them to a future period, under the idea that they will await his convenience; for he is likely enough in that case to deceive himself, and, on returning to the piece of water, to find only emptiness, where, the year before, there was superfluity. It is far better to secure the requisite number of examples on first coming across the species; indeed, if necessary, the whole stock may be taken, as there is little likelihood of extirpating any kind of Alga.

What few implements are needed in the collection of Algæ are neither complicated nor expensive. The following will be found useful:—

1. A small iron or tin ladle, two inches across, fig. 7. About one-third of the circumference on the right hand side is provided with a number of teeth, three lines long, and bent inwards. A short hollow handle projects from one side of the ladle, whereby it may be attached to a walking-stick.

Fig. 7.



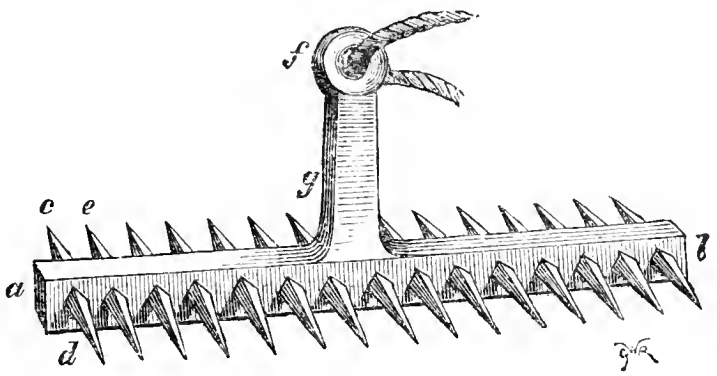
This little instrument serves to fish out plants which lie beyond arm's length; and the teeth may be usefully employed in entangling small species which occur on the surface of the water, such as Rivulariæ, Cylindrospermum, &c.

2. A tiny sieve, such as is sometimes suspended from the mouth of a teapot to intercept the minute portions of the leaves. It must be of very fine wire, and provided with a handle. Its use is to secure floating masses of Desmidiaceæ, Limnochlids, &c.

3. A common iron spoon is convenient for lifting with care the upper layers of mud, where there is reason to suspect the presence of Diatomaceæ and Desmidiaceæ.

4. Where Characeæ are likely to be met with, or, indeed, for dredging purposes generally, Caspary's rake is an

Fig. 8.



admirable instrument, fig. 8. It is made of iron, and is of the following dimensions:—Length, *a*, *b*, ten inches; width, *c*, *d*, from the point of one tooth to the opposite point, three and three-quarter inches; distance between the points of the teeth *c*, *e*, three-quarters of an inch. The handle, *f*, *g*, terminating in a ring, to which a stout cord may be attached, is five inches long. The weight of the instrument must not be less than two or three pounds; if lighter, it is apt to jump over slight obstacles at the bottom of the water, and thereby miss the object to be caught. The length of line, which should be about the thickness of a finger, must of course be adapted to the depth of the water. An Alpine lake frequently requires as much as eighty or ninety feet. For convenience

of carriage, the teeth of the rake may be enclosed in a wooden channel (just as a crosscut saw is generally carried), and the rope tied round and round it. It is a mistake to fix the rake into a long handle (as is sometimes done), not solely on account of the difficulty of transport, but because it can only be used in water of moderate depth. Moreover, it is by no means easy to fix the instrument with sufficient firmness into the wooden handle, and it is consequently liable to be lost, if it meets with an obstruction of more than ordinary size.

5. A sufficient quantity of oiled paper, or some similar material, such as waxed cloth, or india-rubber or gutta-percha sheeting, in which to fold up the specimens, and prevent the water from draining out. Several small parcels can be packed in a larger piece of sheeting, and these again placed in a bag, to be carried across the shoulders.

6. A number of small bottles with wide mouths, for the purpose of holding Diatomaceæ, and similar minute specimens. Cork stoppers are to be preferred to glass, as the latter are apt to get loose and fall out from the constant friction of sandy particles, whose presence it is impossible to avoid. Besides, glass stoppers make the bottles both heavier and more expensive, without any corresponding return. The bottles may be safely carried in the breastpocket of a coat—that is, for short expeditions. For longer journeys, and on occasions where many bottles must be carried, it is best to provide a kind of knapsack, not too large, in which they may be laid, one against the other. To prevent shaking or breaking, some paper or strips of pasteboard may be laid between each bottle.

7. Lastly, it is of the utmost importance to be provided with a good lens, or a pocket-microscope, so as to be able to distinguish in a moment, and on the spot, useless from useful matter.

There is no need to recommend a stout walking-stick and a pocket-knife, as no sensible botanist would think of

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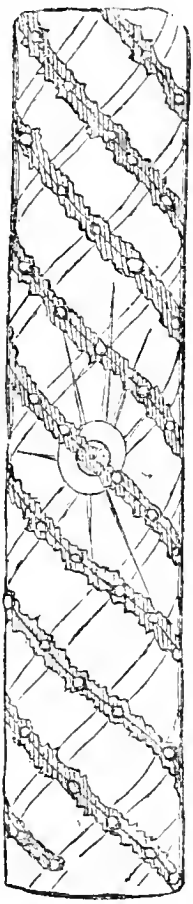

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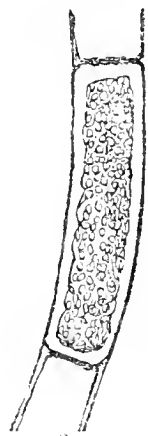

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Spirogyra.

going on an expedition without being provided with both the one and the other. The former especially is indispensable to the Algologist, as it forms a ready handle for his ladle and sieve.

With these few instruments the collector of Algæ is prepared for his outdoor work. A tin vasculum, such as is commonly used in gathering Phanerogamia, need not be rejected; still it is by no means a necessity, because the Algæ are sufficiently protected by the waterproof paper or sheeting. Nor are they of the same fragile nature as the higher plants. Besides, a considerable portion will be contained in the bottles. At the same time, however carried, care must of course be taken not to squeeze the specimens too closely together.

As soon as the stock of specimens is brought home, the first business of the collector will be to place them (each species by itself, as far as may be) in glasses of water (which should be, if possible, quite soft), in order to keep them fresh until he is prepared to examine them. Many species may be preserved in this way for several days without spoiling, especially if the water in which they are placed be in some quantity, and is changed every day. Others however, the Vaucheriæ for instance, perish very quickly, and cannot be preserved for long. These therefore must be attended to first. But even when any of these are completely lost, it is well not to throw them away until they have been carefully searched for Diatomaceæ, many of which will survive the decay of the plants to which they were clinging when first removed from the water. A small quantity of muriatic acid may be poured into the glass, as this has a tendency to check putridity, and then the Diatomaceæ may be separated at leisure.

If from want of time, distance from home, or any like cause, the specimens collected cannot be at once prepared, the best plan is to place them in a bottle, and pour over them a quantity of gin, which may be procured almost anywhere. It is true the alcohol destroys the colour of

the plants, and turns them yellow or brown; but even that is to be preferred to losing them altogether. At the same time the collector should not forget to note the fact of their having been immersed in alcohol, otherwise, if exchanges are made, strange mistakes may arise as to the original colour of the specimen.

As may be supposed, plants which have grown in swiftly flowing streams are more liable to decay after they have been gathered, than those whose home is the stagnant pond or marsh, since the conditions of life in the latter are not so much interfered with by their removal; indeed, they will often continue to live and vegetate in a room, provided attention be paid to the chemical quality of the water in which they are found.

As this little work is intended for the collector and not for the systematist, nothing will here be said with regard to the *genera* into which the Algæ have been divided. That portion of their history must be sought for in other works, though of course in this, as in every other department of Natural History, an intimate knowledge of both genera and species is essential to the student. But, for convenience sake and to avoid repetitions, we will, in the following pages, confine our treatment of the subject to certain heads, corresponding in some degree to the natural divisions of systematic authors.

[Having given on a preceding page one or two examples of the lovely patterns which distinguish some of the filamentous Algæ, it will not be amiss to insert here some specimens of the families of Diatomaceæ and Desmidiaceæ. The figures will assist the young student in discriminating the members of these minute, but important, divisions of the vegetable kingdom; they will also help to point out to him what wonderful treasures lie within his grasp, ready to be seized as soon as his eye and hand are sufficiently educated to make them his own. In the accompanying Plates (II. III. IV. V.) the Diatomaceæ are represented by figures 9 to 14, the Desmidiaceæ by figs. 15 to 23.—Ed.]

CHAPTER II.

OF THE DIATOMACEÆ.

THESE TINY MEMBERS of the great vegetable kingdom are generally the first to engage the attention of the collector, for their distribution is almost boundless. I suppose there is scarcely a single piece of water anywhere which does not contain at least some individuals of the commoner species. They are to be found alike in the lake that crowns the mountain-top, and the swamps and peat-beds which fill the lowest valley; in the water-course employed to irrigate the meadows; in the broad ocean and the shallow puddle left by the overflowing of a ditch. The brackish water, where the tidal river meets the sea; salt-works and salt-pits; even inland lakes, which have a trace of salt in them—each affords a rich variety of characteristic Diatomaceæ, varying according to the chemical quality of the water.* They are to be frequently found also on rocks and masses of stone, damp from overhanging trees, or from the constant trickling of water. There they nestle among the tufts of moss, or the layers of Oscillatoriæ; or, in company with other minute Algæ, form a slimy mass of a brown or olive green colour on the face of the bare rock. Never let the collector pass by a spot of this description without giving it a close examination. He will be often rewarded with some of the rarest and most lovely species.

* It is quite astonishing what a slight infusion of salt suffices to fix the character of the Diatomaceæ. For example's sake I may mention a lake in Hungary, and some pieces of water in Southern Moravia, which contain an inappreciable quantity of salt, nevertheless the Diatomaceous forms answer exactly to those usually found in brackish water.—J. N.

In any case he is tolerably sure to come across good specimens of other Cryptogamic orders.

The fact that the separate valves of the Diatomaceæ are protected by an almost indestructible coating of silica, allows of their being recognised years after the organism itself has ceased to exist, as may be seen in almost any dried-up pool. Nay, countless ages may pass away, and still the valves, on being brought to the light of day, will exhibit their delicate markings as clearly as though the hand of the Creator had sculptured them but yesterday. Numerous deposits of these peculiar Algæ are to be found in different parts of the world. It is sufficient to mention San Fiore in Tuscany, Franzenbad in Bohemia, and Berlin, as well-known examples. This remarkable quality of endurance naturally leads us to look for traces of their presence in localities where we should not usually search for the Algæ. Guano, for instance, is rich in beautiful forms. Dwellers by the seaside may furnish themselves with numerous species, which vegetate in the unknown depths of the ocean, by a microscopic examination of the contents of the stomachs of fishes, mollusks, and medusæ; a task not much to the taste perhaps of the beginner, but one which we would recommend him to undertake boldly, as he is sure to meet with a rich return.

So minute are the Diatomaceæ, that, with few exceptions, individuals escape the eye of the collector altogether, save when armed with a microscope or powerful lens. Still he should never hesitate to carry off a supply of what may, at first sight, appear to be worthless matter. For oftentimes he will find examples of most interesting species in gatherings which, to the naked eye, seem entirely destitute of vegetation, and, for the sake of these, he must be content to draw a few blanks in the vegetable lottery.

It is rare, indeed, to find Diatomaceæ in any quantity free from admixture with other members of the Algæ, and uncontaminated by mud and sandy particles. Generally

speaking, the cleanest specimens, by which I mean those best adapted for immediate preparation, are the filamentous genera of Melosira, Odontidium, Fragillaria, and Schizonema; also certain parasitical kinds, such as Cocconeis, Achnanthes, Synedra, Gomphonema, Licmophora, &c., which often cover the plants to which they are attached to such an extent as to hide the original form.

With regard to the fossil Diatomaceæ it is a singular fact, that although they exist in such countless quantities, they are nevertheless ranged under a very small number of species.

As in the case of the Algæ generally, the outfit required for gathering Diatomaceæ is of the simplest kind. A common iron spoon, to scrape the surface of mud; a few small bottles, wide-necked and cork-stoppered; a quantity of oiled paper, or some similar material. With these few articles the botanist may safely commence an expedition in search of these minute plants.

[The collector will often come across likely-looking spots, lying beyond the reach of his arm; perhaps a mass of weeds in the middle of a wide ditch, or a tempting hollow at the base of a steep slippery bank. To meet this contingency, he should provide himself with an ounce vial, broad-brimmed and wide-mouthed, and, besides, a stout india-rubber ring. The bottle, when required, can be easily attached to the end of a walking-stick by means of the ring (as shown in fig. 24, Plate v.), and then inserted among tufts of Algæ, &c., at some distance from the side of the pond or stream.—Ed.]

CHAPTER III.

OF THE FREE DIATOMACEÆ.

The Diatomaceæ may be conveniently divided into two classes. the free species, or those which have an independent existence; and the stipitate, or such as are attached to other objects, generally the larger Algæ, by means of a stalk. This kind of classification, though purely arbitrary, is not without a certain importance, so far as the purposes of collection and preparation are concerned; for, as it is one of the main points in a well-ordered herbarium to retain the natural habit of each plant, we must not overlook the various modes of growth to which the Diatomaceæ are subject.

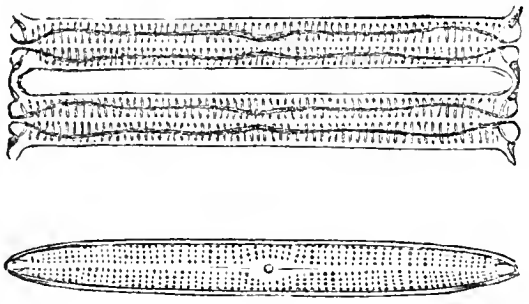
[Acting on the Horatian maxim, that

> 'Segnius irritant animos demissa per aures,
> Quam quæ sunt oculis subjecta fidelibus,'

I add here a few examples of the two classes of Diatoms referred to above. Figs 25, 26, Plate v., represent members of the 'Free' genera, Navicula and Pinnularia.

In these it will be seen that each plant is a separate and independent individual; whereas in those which follow, individuals are attached together, or to some other body, either by a slender cord, or by a stem, from the ends or sides of which they are produced; in other words are 'Stipitate:' for these see Plates vi. and vii.

A third form includes the Frondose species, or those in which numerous individual frustules are enclosed in, and held together by, a coating of gelatine; bearing, in this state, a strong resemblance to the frond of a tiny seaweed. Figs 31 to 34 (Plate viii.) belong to this group.—Ed.]



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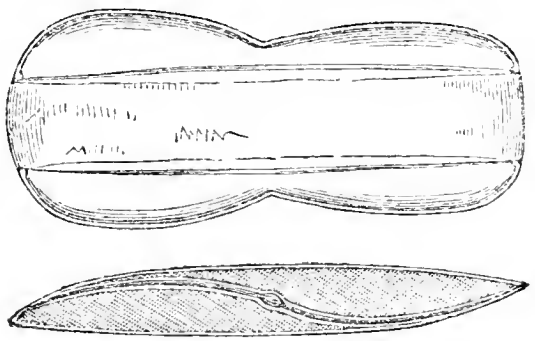

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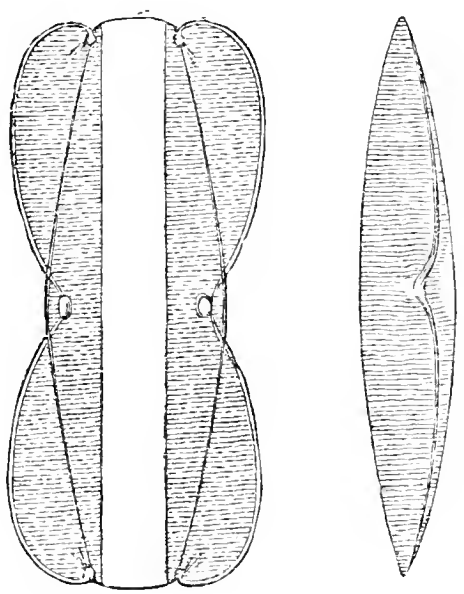

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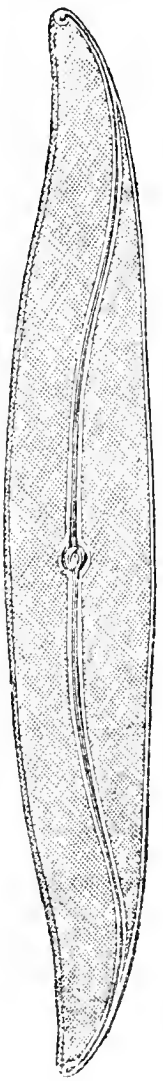

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9. Toxonidea Gregoriana.
10. Donkinia carinata.
11. Amphiprora maxima.
12. Diadesmis Williamsonii.

The free growing members of the family (or those which are in no sense parasitic) are found entangled among the tufts of filamentous Algæ, Oscillatoriæ, Mosses, &c.; or we see them below the surface of the water, wherever the soil, or a stone, or fallen leaf, is stained with a yellowish brown hue. In the latter case the colour is almost invariably due to multitudes of Naviculaceæ and Nitzschiæ, genera which usually prefer shallow spots, only a few inches deep, though occasionally they occur in considerable depths, as for example in Alpine lakes. In swiftly flowing streams they become more scattered, and numbers of them remain suspended in the foam, consequent on the water beating violently against stones and other obstacles, and thus may be easily collected without any admixture of sand and mud. In like manner they often rise to the surface with the bubbles of gas, which are disengaged from water-plants under the influence of the sun's rays. Whenever these foam bubbles are seen to be tinged with a brown colour, the collector knows at once, that they are charged with numerous specimens of the plants he is in search of, and he has only to skim them off into a wide-mouthed bottle to be sure of ample materials for study on his return home. Those individuals which are caught among the filaments of Algæ, or Mosses, must be gathered with the latter, care being taken to drain as little moisture as possible from the tuft, lest the Diatomaceæ escape with it. Let the whole mass be carefully laid in oiled paper, and on afterwards washing it in clean water, the lesser Algæ will be disengaged from their temporary nidus, and after a while sink to the bottom of the vessel, when the superfluous water may be poured off. If it is desired to dry the sediment at once, this can be managed by filtering it through some fitting material.

It is less easy, however, to separate them from the Oscillatoriæ, because the latter are so fragile, that it is almost impossible to prevent numerous fragments of their filaments from being mingled with the Diatomaceæ. To

get rid of these, the objects to be cleaned should be placed in an evaporating dish of porcelain, or in test tubes (such as are used in chemical laboratories), into which some strong mineral acid—muriatic or nitric—has been previously poured, and the whole suspended over a spirit-lamp. By this means the fragments of Oscillatoriæ and other organic matter will be dissolved, leaving a residuum of the silicious coats of the Diatomaceæ (which are practically indestructible), and also whatever flinty particles of sand may have been introduced: these latter can be got rid of by washing, in a way to be presently described.

During the boiling which ensues, means must be taken to let the vapour escape that rises from the heated acid, by placing the apparatus, for instance, on the hob of a fire-grate, so that the steam may be carried up the chimney. If this precaution is neglected, serious damage is likely to ensue to articles in the room, the lenses of a microscope will be spoilt, and any metallic substance is sure to be tarnished, not to mention the injury that may be done to the observer himself, from imbibing the poisonous vapour.

How long the boiling should continue can be determined only by practice and experience; a few minutes are generally sufficient. Sometimes, however, a second application of acid is needed, before the whole of the organisms are dissolved. The best test, perhaps, of this having been accomplished is the clear bright appearance of the acid that remains in the tube or saucer, and then the Diatomaceous valves may be considered as thoroughly cleansed. To clear them of the acid, empty the mass into a tolerably large glass of pure water, and allow the Diatomaceæ to sink to the bottom. Immediately pour off the water, taking the utmost care not to disturb the sediment, and introduce a fresh supply, which must, in its turn, be poured off, and the glass refilled. This should continue until a strip of litmus paper ceases to be tinged with a

reddish hue; a proof that not an atom of the acid is left in the glass.

The greatest attention must be paid to this cleansing process, for, should it be carried out carelessly or incompletely, the valves, on account of the acid still clinging to them, will make very imperfect preparations for the microscope. Supposing, however, that all has been done as it should be, the flinty coating of the Diatomaceæ suspended in the water will be seen to give it a sort of flickering appearance. Time must be given them to settle on the bottom of the glass, and then they may be passed through the filter and dried; or, if not wanted immediately, they may be kept in alcohol for future observation.

The species which lie on the surface of mud must also go through a process of cleansing, for it is exceedingly difficult to collect them in so pure a state as is needed for a really good preparation. They can rarely, in fact, be gathered without a large infusion of sand and earthy ingredients, though, of course, the more careful the collector is in taking them up, the less will be his trouble and anxiety afterwards.

Generally speaking, these species appear as a yellowish brown deposit at the bottom of the ditch or shallow pond in which they are found. The finer the weather and the brighter the sun, the richer and more conspicuous is this deposit, because these circumstances are favourable to the vegetative powers of the Diatomaceæ, which then move with considerable activity, and draw themselves towards the light, forming a thin layer, which may be lifted carefully off the surface of the mud with an iron spoon, and dropped into a wide-mouthed bottle. Sometimes, under the influence of the sun's rays, causing gases to bubble up from the underlying mud, myriads of these tiny plants are caught by passing fragments of Oscillatoriæ and other weeds, are raised to the top of the water, and may then be secured in a perfectly pure condition.

When however, as is more usually the case, earth and

sand are mixed with the captured Diatomaceæ, the former must be got rid of by the process of washing alluded to just now.

There are different arrangements for effecting this; in the simplest, a few wine glasses are all the apparatus needed. Empty the contents of a bottle into one of these, and shake them well together. Let the glass remain at rest for a short time, until the heavier particles have sunk to the bottom; then pour the water slowly and carefully into another glass, and the Diatomaceæ and other light bodies will be carried with it. As some of the material might be lost by clinging to the outside of the glass, in consequence of the slow passage of the water, it is a good plan to smear the edge with a little tallow or suet: this will cause the water to flow in a steady compact stream. Now let the vessel be quite still as before, so as to allow of the heavier ingredients once more subsiding, and again decant the contents, leaving the residue in the glass. This process may be repeated again and again, until the Diatomaceæ are entirely purified from all admixture of mud or sand. Indeed, by the same mode of proceeding, the larger species may be effectually separated from the lesser; because, owing to their weight and form, certain kinds are sure to reach the bottom more quickly than their lighter companions. The clearer the water appears to the eye, so much the longer must the glass remain at rest, because, in consequence of their smaller specific gravity, the lesser species take a longer time to sink. Lastly, the separate deposits are to be examined under the microscope, and their contents filtered and dried.

The plan recommended by Okeden is rather more complicated than this, but is perhaps more effectual in the end. The gathering of mud and Diatomaceæ is emptied into a tall narrow vessel—a champagne glass for instance—into which water has been poured to the depth of two inches, and is then to be stirred with a glass rod. The vessel is left quiet until the more solid particles have

separated themselves, and sunk to the bottom. This will take place in about half a minute. The fluid is next carefully decanted into a second glass, and the amount of water lost made up, the same process being gone through five or six times. The sediment in the second glass now contains all the Diatomaceæ and sandy particles, which were too light to subside during the first half minute. To separate these still further, this sediment is treated exactly as was the original gathering, excepting that a longer time is given it (say two minutes and a half), between each decanting. In the same way the contents of the third glass are sorted, only that a still longer period, not less than five minutes, is allowed. Every glass now contains samples of Diatomaceæ, mingled with earthy ingredients of varying weights, the last glass having of course the lightest. To remove the foreign bodies altogether, each mass of sediment is placed in turn in a short wide glass, and about an inch height of water is poured over it, where it is left for a minute or two. As soon as the whole of the contents may be supposed to have settled, a rotatory motion is given to the water, by moving the vessel with the hand in a circular direction. The Diatomaceæ, consisting mostly of thin plates or valves, are raised by the agitation of the water to the surface, while, on the other hand, the sandy particles being more or less round, are rolled upon each other at the bottom, and gradually collect in the centre of the vessel. The fluid is now quickly, but with great care, decanted into a second glass, where the Diatomaceæ are allowed to subside. What remains in the first glass may be again and again submitted to the same process, until it is tolerably certain that not a single Diatom has been overlooked.

In order to effect a separation of the different species, by taking advantage of their varying specific gravities, the following method, introduced by Munro, is excellent, and has the merit of great simplicity. A glass tube, three to four feet in length and half an inch wide, is

suspended, or fixed, in an upright position. To the lower part is attached a short piece of india-rubber tubing, ending in a glass mouthpiece with a fine opening, and provided with a kind of tap, known in Germany as a 'Quetschhahn,' which may be freely interpreted 'spring-tap.'* The Algæ having been partially cleansed from sand and dirt, the mass is poured into the upper opening of the tube, and a short time being allowed for settlement, the tap is opened, and a portion drawn off into a glass. The tap being again closed, and a few minutes allowed to pass, some more of the water is run into a second glass, and so on, a longer period being allowed between each opening of the tap, until the whole of the

* As this peculiar and most useful form of tap is, I believe, unknown, or nearly so, to English Diatomologists, I append a short description. It consists, as shown in the accompanying figures, of an elastic wire bent round to form two parallel sides, which are again bent at right angles to its axis, so as to cross one another, and each ending in a flat button A, B. Its elasticity, when made to grasp the india-rubber tubing, completely prevents the passage of a fluid. If it is desired that the fluid should escape from the tube, it is only necessary to press the buttons A, B, upon which the two sides separate to any required extent. On releasing the buttons, they immediately fall back to their former position, and the flow of liquid is arrested.

This instrument (which may be procured at Mr. Baker's, 243, High Holborn) is greatly to be preferred to the ordinary stop-cock for use in washing Diatomaceæ; being cheaper, more easily cleaned, and far less liable to get out of order, or to be choked by sand or mud.—Ed.

Fig. 35.

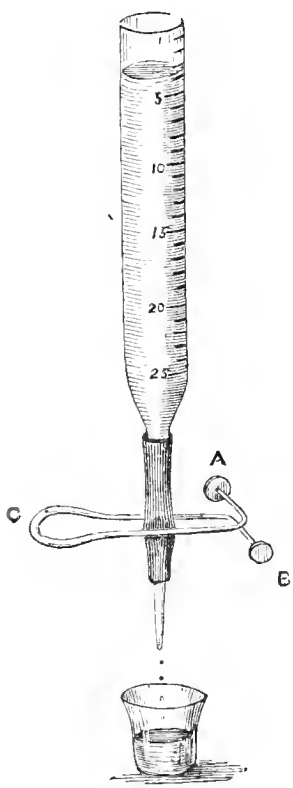
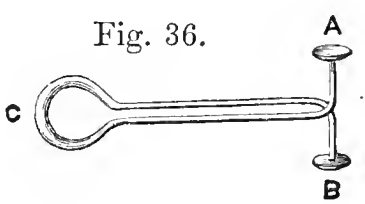
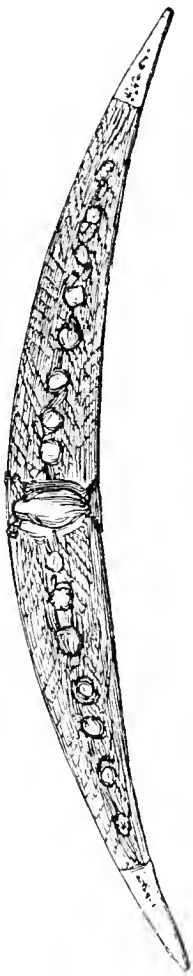


Fig. 36.





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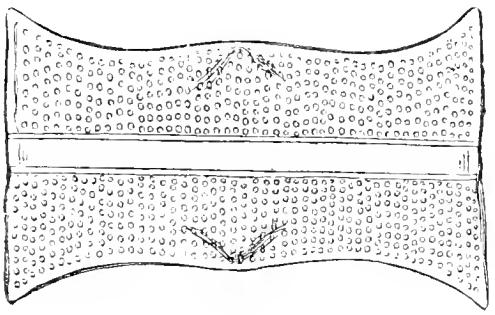

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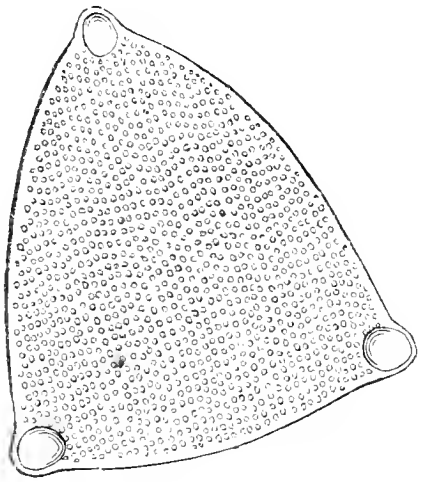

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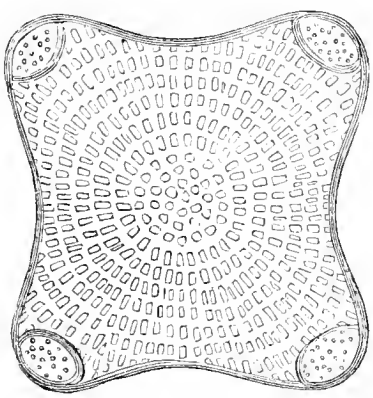
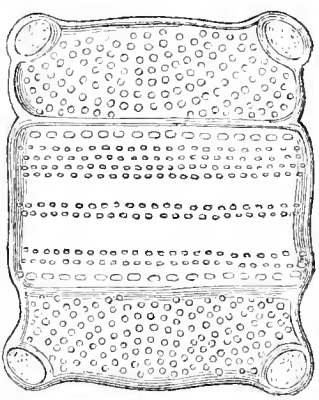




14

13. Triceratium striolatum. 14. Amphitetras antediluviana.
15. Closterium Liebleinii.

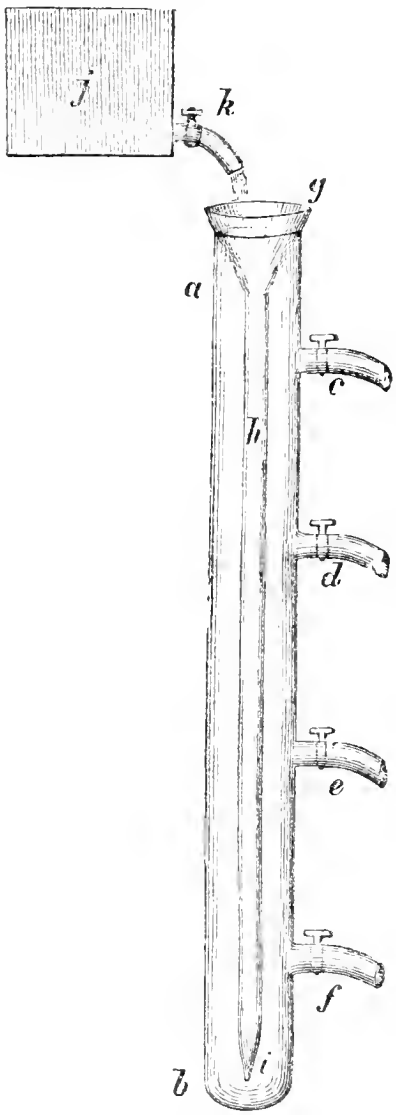
fluid is received into several glasses. If now these are examined, it will be found that they contain individuals of different species, for the heaviest sorts sank first to the bottom of the tube, and were the first drawn off, the lighter swam longer on the surface of the water contained in the tube, and were the last therefore to leave it.

Another plan, as ingenious as it is easy to put in practice, is that recommended by Reinicke, the principle of which is founded on the peculiar property, possessed by the Diatomaceæ, of pressing towards the light. Having collected a quantity of mud, which is seen to be overlaid by a deposit of Diatomaceæ, it is spread out on a shallow plate, a common dinner plate answers the purpose very well. Upon this is laid a piece of thin linen, or canvass, or cotton stuff, and sufficient water gently poured upon the whole to cover it entirely. The plate is then left near the window of a room in a clear light, or, better still, where the full rays of the sun may fall upon it. The tiny organisms immediately begin to creep through the meshes of the overlying cloth, and, in two or three days, form on it a thickish coating (free from all earthy matter), which may be taken up by means of a camel's hair pencil, and laid upon a slip of glass. Of course this process is available only so long as the plants are fresh and full of life. If left too long in the room, they lose their vitality, and must be got at by some other means. Another point to be remembered is, that it can be employed only with certain species, such as the Nitzschiæ and Naviculæ, whose movements are perfectly free and active. There are numerous genera in which the individuals have but slight inherent powers of motion; these cannot be prepared after this method.

Gerstenberger's plan of propagating Diatomaceæ in confinement, depends on nearly the same principle He also spreads out the mud on a plate or shallow dish, and places it near a window in the full light of the sun. Stimulated by its rays, the plants begin to multiply

rapidly, forming a brown layer on the surface of the mud. As soon as a sufficient quantity is produced, the water is carefully poured away, or (preferably in my opinion) is drawn off by the aid of a small glass syringe. The mass is now to be swept up with a camel's hair pencil, and either deposited at once on a slip of glass, or immersed in clear water. The mud remaining in the plate may be a second time moistened and placed in the sun, and the collection of the Diatomaceæ repeated as before. By degrees, however, the vitality of the little plants exhausts itself, and it is necessary to revive their vegetative powers. This may be accomplished by creating for them an artificial spring and winter. And there is, in truth, no difficulty in producing these unseasonable seasons! You have only to allow the water to evaporate, and the mud to become nearly, not quite, dry. Then pour fresh water over it, and once more the Diatomaceæ break up, and vegetation commences anew. In this way, gatherings originally poor may be made to yield an abundant supply of plants.

Fig. 37.



Another contrivance for obtaining the Diatomaceæ in a pure state is the washing apparatus of Benning, fig. 37.

It consists of a glass cylinder, two feet six inches in height and two inches wide, on one side of which four holes are pierced, *c*, *d*, *e*, *f*, the lowest at four inches from

the bottom, the others being about eight inches apart. Each hole is provided with a short tube, of glass or gutta percha, and a stopcock, or spring tap, so that water may be drawn into vessels placed below, through either of the holes, and in any quantity required. At the apex of the cylinder a funnel, *g*, is placed, and to it is attached a narrow glass tube, *h*, of sufficient length to reach almost to the bottom of the cylinder. To the lower extremity of the tube, *h*, a kind of mouthpiece of glass is joined (a short piece of india-rubber tubing will effect the junction), drawn out into a very fine opening. Above the funnel, *g*, either placed on a stand or fixed against the wall, is a tin vessel, *j*, with a short pipe, *k*, leading into the funnel. This vessel is for the reception of water.

The method of using this little apparatus is as follows:—The Diatomaceæ, roughly freed from mud and sand, are poured into the cylinder, *a*, *b*, and immediately sink to the bottom. The funnel, *g*, being replaced, the tap, *k*, is opened, and water begins to flow down the inner tube, *h*. The effect of this is to cause a grand disturbance among the imprisoned Diatomaceæ, which are forced up the sides of the cylinder, *a*, *b*, the lightest of course being the highest. On opening the uppermost, *c*, of the four side sluices, the water, loaded with Diatomaceæ, issues into a wineglass, or some similar vessel, and this should be continued as long as the fluid remains thick. As soon as it appears clear and bright, let the next tap, *d*, be opened (the upper one still being allowed to discharge its contents), and the water caught in a second glass. This second glass will then contain all those Diatomaceæ which were too heavy to rise to the level of the uppermost tap, *c*, but at the same time too light to sink below the level of the third tap, *e*. And so the process is continued until each of the taps has been opened.

It will be well to bear in mind, that the flow of water from the reservoir, *j*, can be regulated very nicely, and the quantity discharged lessened or increased, by means of the

tap, *k*, leading into the funnel. The amount of disturbance, also, to which the Diatomaceæ are subjected can be altered at will, by having mouth-pieces of different sizes made for the funnel tube, *h*, so that the apparatus is completely under the control of the operator, and any degree of washing can be given to the contents of the cylinder—the column of water issuing from the funnel and the opening of the mouth-piece below being made to bear a certain relation to each other.

The Diatomaceæ being now cleansed from all impurities, the next step is to put them away in the herbarium. If the quantity be sufficient, it is a good plan to lay them (using a camel's hair pencil for the purpose) on stout paper or cardboard, and there let them dry. Should they be wanted for examination under the microscope, it is easy to take up a portion, about the size of a pin's head, and lay it on a glass slide. If, however, the original supply is small, the whole may be placed at once on a glass slide, protected by a thin glass covering. The advantage of this method is, that the object is always ready for microscopical observation and comparison, and the same preparation may be examined any number of times. Care, however, must be taken, while laying on the drop, that the individuals are not too crowded together, but that each one stands out distinctly; otherwise the passage of light is interfered with, and a dark shapeless mass is all that meets the observer's eye.

The scientific value of each preparation is increased by having at hand some specimens in a 'crude' state, that is to say, with the endochrome in situ, and not removed by an acid. The difference between these two states is this: when the valves have been submitted to the action of a strong acid, the delicate sculpturing of the silicious coat comes out, under proper illumination, in a marvellous way; but the endochrome has entirely disappeared; the plant is, in fact, a mere shell. In the other case, when the individuals are not submitted to an acid, and are examined in a fluid, the markings are scarcely visible;

very often they are not to be seen at all; but the contents of the valves can be made out clearly enough. For this last purpose, then, the plants should be put away in small bottles, filled with very dilute alcohol. When required for use, let the bottle be well shaken, insert a glass rod, and some of the frustules are sure to cling to it, and be drawn out. The drop may then be placed on a slide, and the mixture allowed to evaporate.

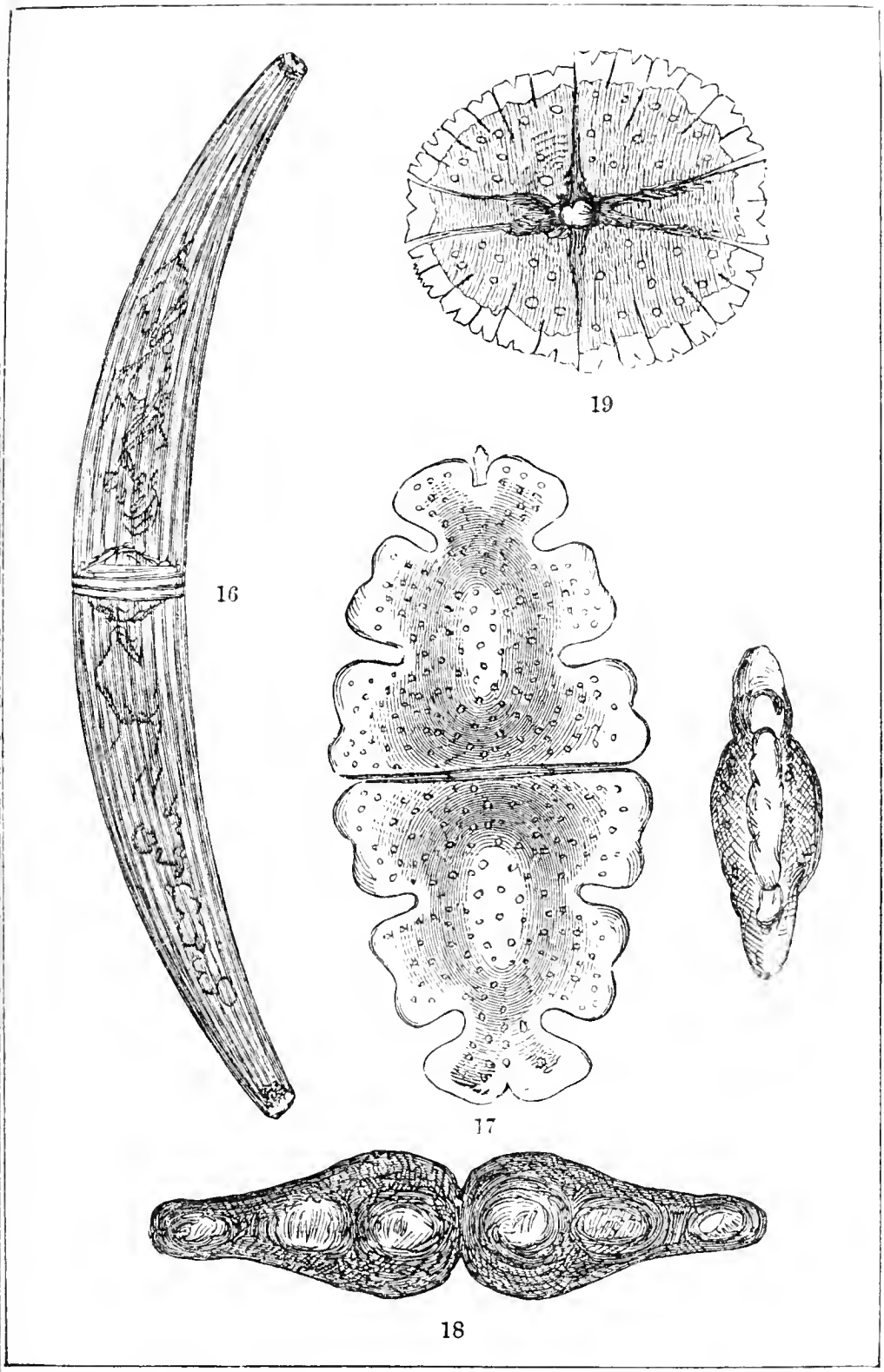
If, as is often the case, especially with the fossil species, the valves will not adhere to the slide, recourse must be had to a very thin solution of gum arabic. By placing a minute drop on the glass, and then immersing the specimens, their adhesiveness is ensured. However, this plan should only be resorted to in extreme cases, for the residuum left by even the purest gum is very apt to interfere with the beauty of the preparation, and to spoil the delicate markings of the valves.

CHAPTER IV.

OF THE STIPITATE DIATOMACEÆ.

THE FACT that certain kinds of Diatomaceæ are attached to other bodies by a footstalk or pedicel, not only forms a convenient ground of division to the collector, but has a specific value in the eyes of the systematist. That this is so is proved by such genera as Cymbella (*Agardh*), and Cocconema (*Ehrenberg*), Sphenella (*Kützing*), and Gomphonema (*Auct.*), Achnanthidium (*Kützing*), and Achnanthes (*Bory*), which are respectively separated solely on this account. Cymbella and Cocconema, for instance, are precisely the same in form and appearance, except that the former is free and the latter stipitate. So with regard to many species of Synedra, great attention is paid to the manner in which they are attached, some being adherent during the whole term of their existence, while others become free at a very early stage. And a single glance at the genera Podosphenia (*Ehrenberg*), Rhipidophora (*Ehrenberg*), and Licmophora (*Agardh*), is sufficient to show how much of the characteristic differences existing among these plants is made to depend upon the existence and position of the footstalk.

The stipitate Diatomaceæ must naturally be searched for in somewhat different localities to those in which the free species love to dwell. They are, in fact, to be found adhering to the larger Algæ and similar water plants, often in enormous quantities. If the smallest atom of one of these loaded plants is separated from the parent branch, and carefully spread out, with the aid of a needle, on a glass slide, then allowed to dry, and submitted to the microscope,



16. Closterium striolatum.
17. Euastrum oblongum (front view).
18. Euastrum oblongum (side view).
19. Micrasterias rotata.

a whole forest of parasitic Diatomaceæ will come into view. The worst of this drying process is, that, in the species with long pedicels, the connection between the head and the stalk is almost sure to be broken, the former separating and falling to the ground. The only way to avoid this is to keep the plants in a mixture of one part of alcohol to six parts of water. The same solution is recommended as a preservative for many species, which are united together and form a long chain, as for instance Odontidium, Melosira, Diatoma, and Tabellaria.

In searching for these minute plants, the collector will often be guided by the reddish-brown tint, which colours the Algæ on which they are growing, and which betrays their presence. This is especially the case in the bright sunshine, when it often happens that tufts of weed float on the surface of the water, upheld by the gases which have been generated by its rays. The quantity of Diatomaceæ, which are sometimes found on the larger Algæ, is almost incredible. Species of the genus Cocconeis (Plate VIII. figs. 38, 39) not unfrequently clothe Confervaceæ (for instance, Cladophora glomerata) with a deep red brown colour, to such an extent that not a trace is to be seen of the original green tint of the Cladophora. The Polysiphoniæ and Ceramia are not unfrequently so completely hidden under masses of Synedra and Achnanthes, that in point of fact they become, not independent plants, but the invisible axis of a coating of Diatomaceæ! Others, however, of the stipitate species occur more rarely. To secure these, the collector must not forget to examine closely the various filamentous Algæ he may chance to come across on his excursions, and to carry off a small piece with him. He must be careful, too, not to overlook those plants whose acquaintance he has already made earlier in the season; for it often happens that a colony of Diatomaceæ will fix themselves on an Alga late in the year, of which not a specimen appeared when the plant was first examined.

In many species (as, for instance, Melosira varians, Odontidium mesodon, &c.), numerous individuals are united together so intimately as to form a sort of chain. These, on being detected, may be at once removed from the water, laid on paper or glass, and dried. But this must be done while the plant is still fresh, for, as soon as its vitality ceases, the links of the chain separate, and the whole falls into a mass of minute fragments. The connection, however, may be preserved for a long time by immersing the plant in the alcoholic mixture mentioned above.

Another manner of growth observed among the Diatomaceæ is that of an amorphous mass of gelatine, or gelatinous tubes, enclosing numerous individual plants. Each tube or sheath forms a kind of frond, adhering at one extremity to the larger Algæ, or some similar object under the water. Of this kind are Encyonema, Homœocladia, Schizonema, and numerous other genera, in which the frond is persistent; while in Colletonema and Frustulia the sheath appears to be of a more temporary nature; in fact, to be an abnormal development due to the influence of some unknown causes, rather than the regular growth of the plant. The beginner will be better able to judge of the structure of this group of Diatomaceæ by consulting Plate IX., as also figures 31 to 34 on Plate VIII.

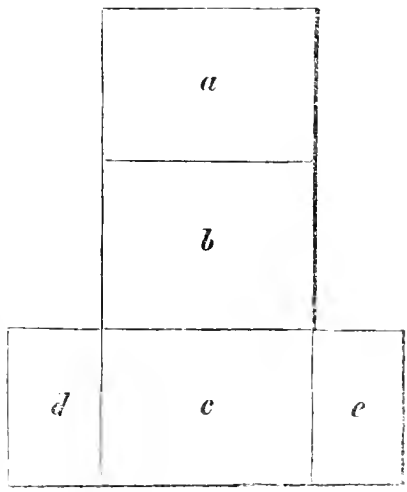
Finally, in Gomphonella olivacea the stipes, or footstalk, appears half dissolved in a kind of mucous matter, in which the wedge-shaped frustules are embedded.

Such of the Algæ as have been laid on paper may be put away as soon as they are thoroughly dried, without any further process but that of attaching a descriptive ticket to each, of which more will be said hereafter.

Those, however, which have been laid on glass, must be placed for preservation in a paper envelope. The shape of this envelope is of sufficient importance to warrant a figure and description, for upon it depends the future safe-keeping of the slide. The latter, in fact, must lie so firmly in its covering, that the tender plants may not be rubbed off in

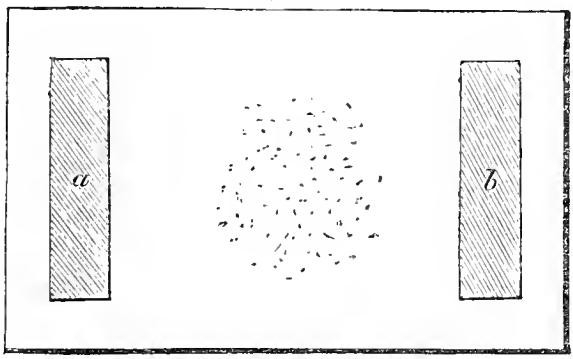
the unavoidable removals from the herbarium, or from any accident to the papers in which they are contained. The safety of the Diatomaceæ is best secured by making the envelope of the form annexed, fig. 43. The slide with its deposit is laid on the square, *b*, face upwards. The upper square, *a*, is carefully folded over it, and the double square thus formed is again folded over the lowest part, *c*. The two wings, *d*, *e*, being successively bent over the whole, prevent the glass from falling out at the sides.

Fig. 43.



Should the plants be of a peculiarly delicate nature (as is generally the case where they have been subjected to the action of an acid), it is a good plan to gum a strip of cardboard on each side of the central mass, *a*, *b*, fig. 44. Upon these a loose piece of glass may be laid whenever the specimens are put away, which may be taken

Fig. 44.



off when the latter are required for examination. I am not sure that this arrangement of the covering glass had not better be the general rule with beginners, instead of the exception, because it ensures the safe keeping of the enclosed Algæ.

If the contents of the slide are not likely to be disturbed, after having been once deposited, or if the valves will not readily attach themselves to the slide, it is better to cover them at once and permanently with thin glass, drawing a ring of Brunswick Black round the edge of the latter, to exclude the air.

CHAPTER V.

OF THE CHARACTERISTICS OF THE DIATOMACEÆ.

BEFORE CONCLUDING my remarks on the Diatomaceæ I wish to call the attention of the reader to the principal characteristics by which they are distinguished from other members of the vegetable kingdom. These are their form and the curious markings of their silicious coats; and with these, varying as they do in the most extraordinary manner, the botanist should make himself thoroughly acquainted.

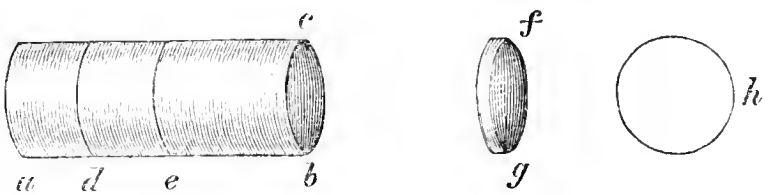
With regard to the form of the plant, he must not be content with a *single* view of the individual, however favourable it may seem. Whichever side is turned towards him, when the specimen is first placed under the lens, his first object should be to roll and turn it on the slide, in such a manner as to expose the other side also to view. This is a difficult business with many of the species (those, for instance, of Fragilaria) which are propagated in long ribbon-like filaments, and which, from the flatness of their outline, lie close against the glass. He must be prepared, indeed, to give up a good deal of time, and to exercise no little patience, before he accomplishes his object; but practice and experience are sure to bring success in the end.

As the language in which authors describe the two aspects under which every Diatomaceous Alga ought to be viewed is often obscure, the reader may get a good notion for himself by the inspection of an ideal figure like that which is here annexed, fig. 45. It represents a column or cylinder, divided into several parts, and, by naming the

long cylindrical surface, *a*, *b*, the 'front view,'* and the base, *c*, *b*, the 'side view,'† we see that the two aspects bear the same relation, as do the long and short axes of the cylinder, to each other.

Now, if we suppose the cylinder to be divided into several very thin sections, *a d*, *d e*, *e b*, &c., in lines perpendicular to its longer axis, it is clear that, so long as the

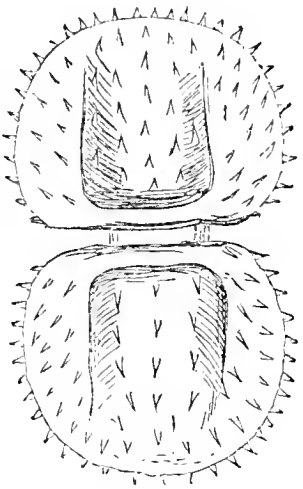
Fig. 45.



rows of sections remain attached to each other, the cylindrical surface, *a*, *b*, appears to the eye of the observer the largest, and is in fact the 'front.' But the whole aspect of the object is changed as soon as the segments are separated and placed apart, as *f*, *g*. Then the base exposes the larger surface, *h*, and is really the 'front' to the observer. However, to avoid confusion, and to have fixed ideas in reference to these parts, the base (or part through which the knife passed in our imaginary section) is held to be the 'side,' while the name of 'front' is appropriated to the part which is cut through, notwithstanding that the so-called 'side' may be more conspicuous and more frequently exposed to view. As the Diatomaceæ propagate themselves by self-division, thereby forming longer or shorter rows of frustules, the diagram given above affords a fair representation of the manner in which the frustules are attached by their 'sides,' as the collector may easily satisfy

* This is the 'primary' side of Kützing and the 'secondary' of Rabenhorst.

† This is the 'primary' side of Rabenhorst, and the 'secondary' of Kützing; so widely do authors differ in their nomenclature.



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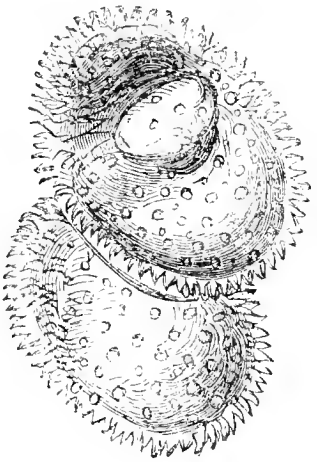

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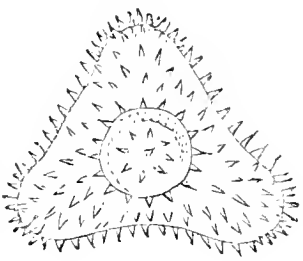

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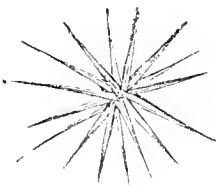

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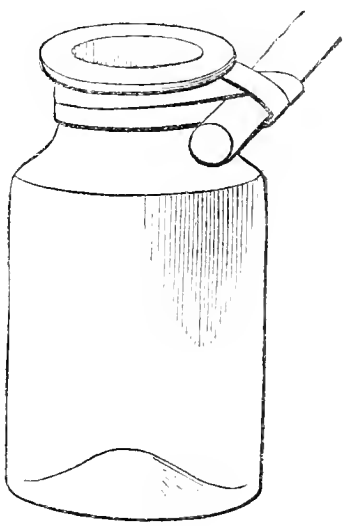

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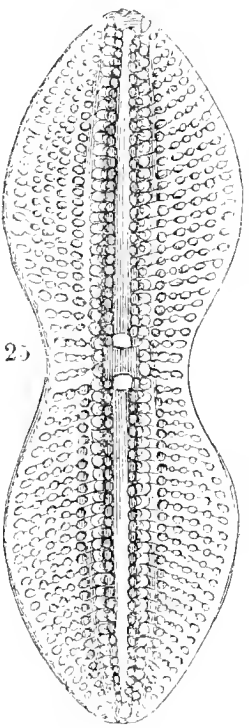

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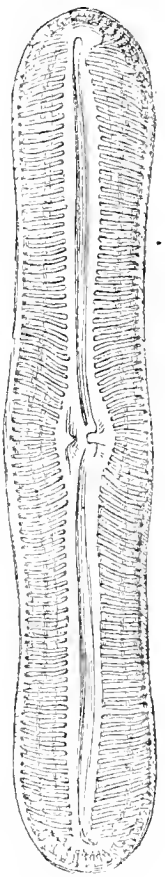

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20. Cosmarium margaritiferum.
21. Cosmarium margaritiferum (empty frond).
22. Cosm. margaritiferum (end view).
23. Ankistrodesmus falcatus.
24. Figure of a Bottle attached to the end of a walking-stick by an india-rubber band.
25. Navicula didyma.
26. Pinnularia major.

himself, especially in the early spring, when the process of multiplication is being rapidly carried on. Melosira varians, Odontidium, Fragilaria, and numerous other kinds, are invariably produced in this manner, and are to be found almost everywhere.

It is more difficult to represent the relation which these two aspects bear to each other in species with unequally developed sides, as Cymbella, or in forms similar to those of Biddulphia and Triceratium, Plate x. It may help to guide the young botanist if he keeps in mind, that the 'sides' are the silicious membranes which, from their enclosing the contents of the plant, are more appropriately named 'valves,' while the 'front' is the frame or hoop, as it is generally termed, which binds the flinty surfaces together. It is on the valves (that is to say, under a 'side view') that we more generally find those wonderful sculpturings which serve the purpose, in a great measure, of distinguishing the species. Perhaps the above remarks will be made clearer by an examination of the annexed fig. 48, in which *a*, *b* represent the two opposite surfaces (valves or sides) of a Navicula, and *c* is the frame (hoop or front) which holds them together.

Fig. 48.

In most cases the Diatomaceæ offer a valve or side view to the observer, the front or hoop being completely out of sight, or only visible as a narrow line or suture encompassing the valve. He is therefore compelled, in order to get a full view of the hoop, to change the position of the frustule by turning it round, which is best done while the plant is immersed in water. If it has been already dried, it should first be allowed to remain a short time in alcohol to get rid of the air, which is almost sure to collect, especially in the larger specimens, and mar their beauty. This being effected, let the plants be placed on a stage plate, a drop of water added, and the whole covered with a

glass.* The next step is to give an almost imperceptible inclination to the covering glass by gently pressing one of the edges with a fine mounted needle. This causes a tiny stream to flow under the glass, by which means the plants are put in motion, and begin to roll over. Meanwhile the object under examination must not be allowed to escape from the operator's view (a mishap which will inevitably occur if the covering glass be too roughly handled), as it is often most difficult to catch sight of it again. Another reason for exercising great care in the use of the needle is, that in very flat species (such as Himantidium) the hoop is so narrow as to form a mere suture. Consequently the frustule, as it turns over, assumes an erect position for a single second only, immediately resuming its former position as the stream of water flows back; so that, unless extreme care be used, the observer will scarcely ever succeed in getting a front view.

It happens occasionally that the plants themselves present both valve and hoop to view, or that they rest against some foreign body in such a way as to show them, without any special manipulation; but these must be looked upon as happy accidents.

If it is desired to make a drawing of these delicate organisms, and I would strongly recommend the collector to do so, this may be accomplished by means of the camera lucida, or Sömmering's mirror or steel disk. For a description of these instruments, and the method of using them, I must refer the reader to works more peculiarly devoted to the microscope.†

The markings on the silicious valves of the Diatomaceæ

* The thicker this covering glass is (in reason), the more convenient is it for the operator; because very thin glasses are difficult to manage, and the water is apt to overflow their edges, and dim the surface. Of course the positive thickness of the glass must be decided by the powers of the objective in use at the time.

† Micrographic Dictionary, Introduction, p. xix.; or Beale's 'How to Work with the Microscope,' p. 20.

are not only very beautiful objects in themselves, but also of great importance in the determination of species. They are dependent on the presence of certain ridges, called costæ, which are connected with an inner membrane, and also of numerous points, more or less fine, which dot the exterior membrane. These points, though sometimes scattered about without order, are more usually seen to be in regular series. Under a low power, the rows of points appear as lines extending across or along the surface of the valve. They are then called striæ,* and, in determining species, it is usual to speak of them under that name, although with a very high power most, if not all, of the striæ are resolvable into dots or points. The differences arising from the fineness, approximation, and position of these striæ constitute the characteristics employed in fixing species. The costa is always visible, even when the valve is immersed in water; but to bring out the striæ and points clearly is a much more difficult matter. Before all things the contents of the frustule must be entirely removed, or the latter will not become transparent. Next to that it must be thoroughly dried; for, if the hollows on the surface of the valve contain any moisture, the passage of the light is interfered with, and the markings rendered indistinct, if not invisible. Lastly, the resolution of the striæ requires not only a really good microscope, but also extremely careful and delicate manipulation, especially as regards the illumination of the object.

In order to dry the frustules quickly and with safety, and to free them from endochrome and other soft substances, they may be exposed for a few seconds to a red heat, which will entirely destroy all organic matter, will dry up any remaining moisture, and leave the silicious valves bright and transparent. The heating is accomplished by placing a

* In fig. 48, the costa or vitta, or median line, is the central line marked *a*, *d*. The striæ are the lines radiating from the centre to the hoop on each side of the costa. The central spot is named the nodule.

quantity of the Diatomaceæ on a thin sheet of platinum, and holding it over the flame of a spirit lamp. As soon as the foreign matter is consumed, the frustules are to be removed from the platinum, and spread out on the stage plate for examination.

It is sometimes more convenient, if the individual plants are very minute and diffused through water, to employ scales of mica in lieu of platinum. But care must be taken in the selection of the mica, as not every piece that comes to hand is suitable for the purpose. A piece must be chosen, which separates easily into flakes, is clean and pellucid, and does not grow dim when exposed to extreme heat. Moreover, it must not be too thick, otherwise the scales are apt to fly apart during the process of incineration ; nor too thin, because, in that case, it becomes dull and opaque under the influence of the heat. Experience alone can guide the operator in choosing the right thickness.

When the frustules have been laid in a drop of water on a scale of this description, the latter is to be held, by the aid of a forceps, at some little distance above the flame, so that the moisture may evaporate without boiling. Strict attention must be paid to this point; for, should the water be allowed to boil, the frustules are thrown on their edges by the action of the air, as it is set free, and long dark heaps are formed on the surface of the mica, like Lilliputian moraines. So soon as the moisture is entirely dissipated, the plate may be lowered into the flame, and there held. At first the preparation assumes a black colour in consequence of the organic matter becoming carbonised : in the next stage it turns red, and finally white ; a token that all the foreign bodies have been got rid of, and the empty valves alone remain.

The period during which the frustules should be exposed to this great heat is a matter of considerable moment, and must be carefully watched. Too short a time is insufficient to destroy the organic substances, and the valves come out dark and impervious to light. If the heating continues too

long, the markings lose their sharpness to a great extent, owing to a kind of glazing operation, which follows on the melting of the alkalies contained in the water. On this account distilled water should be employed, so as to avoid the presence of calcareous salts as far as possible.

After this preparation, the frustules may be placed under the microscope, where a most astonishing sight awaits the eye. So wonderfully minute, however, are the markings brought out by the incineration of the vegetable matter, that, except in a few rare instances, they escape detection altogether when the transmitted light is direct; that is to say, when the rays falling upon the object are parallel to the axis of the instrument. In most kinds of Diatomaceæ the light must be directed obliquely to the lines of striæ, before their minute structure becomes visible even with the highest powers. Oblique light, it may be observed, is obtained by thrusting the mirror to one side of the axis of the microscope. The diaphragm should be removed, to allow free passage to the rays, when the latter will fall, so to speak, upon the edges of the lines, and render them visible. If this proceeding is skilfully managed, the whole system of lines, of which some species possess several, running in different directions, is brought under the eye of the observer.

It is well here to remind the student, that, in order to sharpen his experience and to accustom himself to the detection of these minute points, he should provide himself with what are commonly termed 'test objects,' of which the Diatomaceous family offer some excellent examples. For the lower powers, those magnifying from 200 to 220 times linear,* Pleurosigma attenuatum forms a good test; for

* 'When one dimension only of an object is taken into account, viz. the breadth or diameter—and this is the ordinary manner in which the magnifying power is taken—objects are then said to be magnified so many diameters, or so many times linear. But objects are really as much magnified in the other dimension, or in their entire surface; so that the true expression of their amplification

the higher powers, Pleurosigma angulatum is a fair object. In the former of these two, with direct light, longitudinal striæ are seen; but, when the rays are thrown on it obliquely, a second series of lines appears at right angles to the longer axis of the valve. A threefold system of striation is discovered in Pleurosigma angulatum by careful adjustment of the light, viz. a set of lines perpendicular to the vitta, and two other sets of lines running diagonally across the valve in opposite directions.

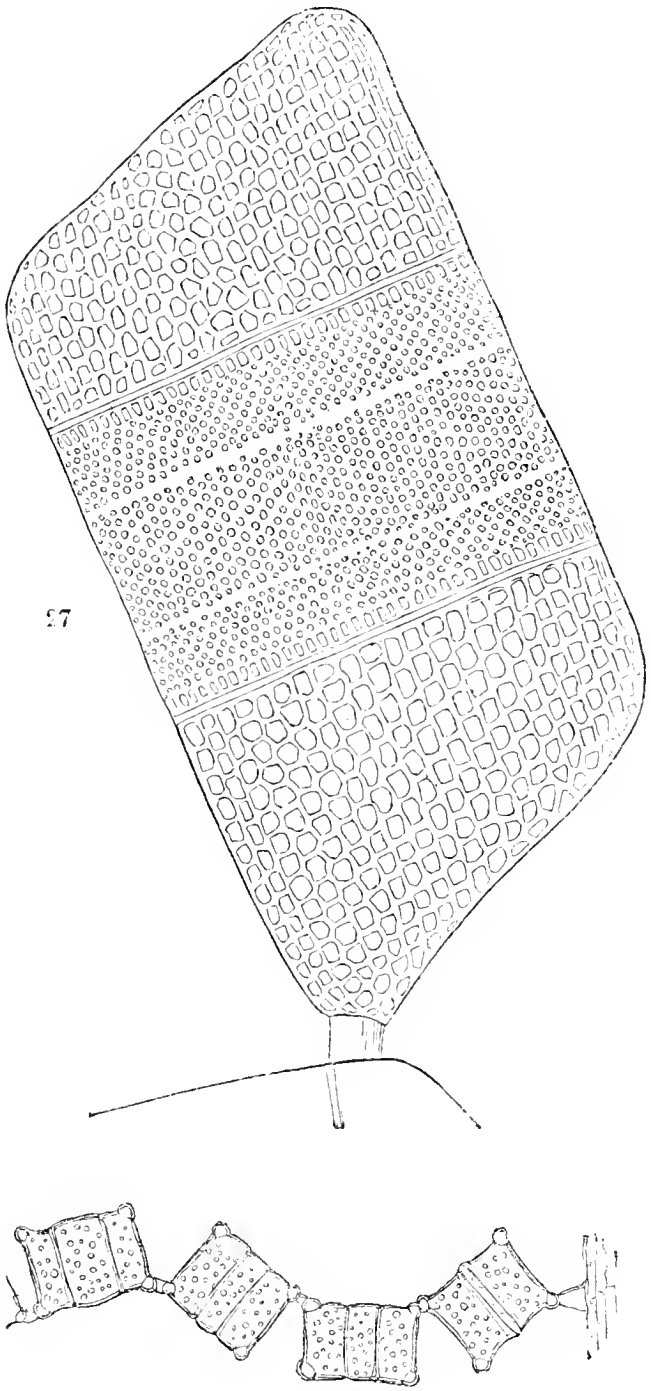
The student will find on several of the plates examples of 'striation.' I would refer him especially to Plates II., V. (25, 26), VIII. (38), XI. (49).

I need scarcely add that, in such delicate operations, where the slightest displacement of the focus changes the whole aspect of the picture, a steady hand and a sharp eye are indispensable.

As the number and direction of the striæ are variable in the different species, though singularly uniform in individuals of the same species, they are most important elements in grouping these plants. For this purpose the lines must be counted, an operation requiring no little clearness of vision; indeed, it is well to give the eye a thorough rest for some seconds before beginning. As a rule, striations showing forty rows or less in 1·1000 inch, are managed without difficulty where the illumination is rightly attended to, and the defining power of the objective is good.* The case, however, is different with the finer markings, and about these there seems to be the greatest

would be given by multiplying that in one direction by that in the other, or by itself; *i.e.* squaring the linear magnifying power. This is called the superficial measurement. Thus supposing a microscope to magnify 40 diameters, $40 \times 40 = 1600$ would express the magnifying power in superficial measure.' (Micrographical Dict. p. 448.)

* Of the two species of Pleurosigma mentioned above, P. attenuatum has 30 longitudinal and 40 transverse striæ; P. angulatum, 52 diagonal striæ in 1·1000.



27. Isthmia enervis. 28. Amphitetras antediluviana.

confusion among authors, who give the most contradictory estimates of the numbers contained in 1·1000 inch.

I think it is more than probable that, when the highest powers are being used, secondary representations, or images, of the striæ appear before the eye, owing to a possible distortion of the rays of light, and that these images deceive the observer, and induce him to note down a larger number than really exists.

The coarser lines may be measured by means of an ordinary stage micrometer; but, for the finer structures, an eyepiece micrometer must also be employed. In either case, the operator must not be content with a single observation of the striæ, but must reckon them several times, so as to be able to draw an average, and get as near the truth as possible.

As however the frustules, minute though they are, have a certain thickness sufficient to interfere with their transparency, a special expedient must be resorted to to obviate this inconvenience; otherwise the valvular markings can never be seen so clearly as is needful in the operations just spoken of. This may be managed by loosening the hold which the hoop, or outside frame, has on the two opposite valves, thereby setting them free, and enabling the observer to view each one as a separate object.

To effect this, let the frustules be boiled in nitric acid, to which chlorate of potassium is to be added in small quantities. After the boiling has continued for about a minute, they must be well washed in soft water, in order to get rid of the acid. If this be carefully done, the intercellular substance which binds the valves together is dissolved, and the latter fall apart.

[For the various methods of mounting the Diatomaceæ in balsam and fluids the reader is referred to works specially devoted to the microscope. There is the less need to introduce the subject here, as it has been already exhausted in Mr. T. Davies' admirable manual, 'The Preparation and Mounting of Microscopic Objects.' Hardwicke.—Ed.]

CHAPTER VI.

OF THE DESMIDIACEÆ AND SIMILAR MINUTE ALGÆ.

We naturally pass from the lowly Diatomaceæ to their as lowly relations, the Desmidiaceæ, since there is so much that is in common between them in regard to their being and their life history, not to mention that the methods of preparation for the herbarium are in many respects identical.

Speaking generally, the Desmids inhabit the same localities with the Diatomaceæ, with the single exception that they are an exclusively freshwater family; not a single species is to be found in the sea. They are to be looked for in bogs, ditches, and ponds, lying in bleak, exposed situations, rarely in shady woods; some, as Closterium, among the filaments of the Oscillatoriæ and Confervæ; others, such as Palmaglæa macrococca, on damp moss, or the surface of wet rocks and cliffs. Boggy heaths, however, are the spots where they mostly congregate, especially where Sphagnum abounds. Swampy places and patches of water scattered over the bog, or shallow drains cut through it, all afford a rich supply of Desmidiaceæ. They also love ditches and holes in which, though the water itself is pure, the soil is of a clayey nature; there they often vegetate in such abundance as to cover the bottom with a dense green film.

The autumn is the best time of year for collecting these plants, and the outfit necessary is much the same as in the case of the Diatomaceæ.

If the Desmids are in any quantity among the stems of the Sphagnum, the latter will have a slimy, jelly-like feel when grasped. Should the collector, on taking up a tuft of the moss, have reason to suspect their presence, he should let the principal part of the water drain away, though with-

out pressing the Sphagnum with his hand, and then wrap the tuft in a piece of oiled paper or oilskin, or better perhaps india-rubber sheeting.

On reaching home the Desmidiaceæ must be washed out of the Sphagnum into a glass, where they will speedily settle on the sides and bottom, and then the water may be slowly and carefully decanted. If the Desmids obtained by this simple process are free from mud and sand, nothing remains but to place them, with a camel's hair pencil, on a slip of glass, as was recommended to be done with the Diatomaceæ.

When they occur as a green stratum on the bottom of a pool or ditch, they may be taken up with a spoon and placed in a wide-mouthed bottle, while the floating specimens can be caught with the 'tea sieve,' described at p. 5. On turning the contents of the phial into a white dinner plate, the Desmids will, in a short time, collect on the surface and sides, and then may be gathered up with a hair pencil, and laid on a glass slide in a pure condition. A second gathering may be made by pouring off the water and earthy deposit, when numbers of them will be found still clinging to the plate.

They may also be separated from mud and sand by Okeden's method, mentioned at p. 20; and the collector has the additional advantage, in this instance, of having them sorted into larger and smaller specimens.

In short, most of the arrangements in use for cleansing the Diatomaceæ are equally applicable to the plants before us, provided neither heat nor acids be brought into play; for the Desmids, having a membranous envelope entirely destitute of silica, cannot withstand the action of fire, or the corrosive operation of an acid, like the flinty coated Diatoms.

The greater number of the Desmidiaceæ are free, as may be seen from the examples in Plate XI. figs. 50 to 53.

In other cases we find several individuals grouped together in the form of a star or disk, see Plate XII.

In some instances, the individual is constricted in such a manner, as to have the appearance of two valves united together centrally: of these, fig. 58, Plate XII., is an example.

The reader will observe the same peculiarity of structure in the figures ranging from 17 to 22, already given in Plates IV. V. Other species, again, are arranged in long filaments; or ribbon-like colonies, fig. 59, Plate XIII.

These filamentous Desmids generally yield very clean preparations.

It will be seen that Hyalotheca is enveloped in a thick coating of mucous matter: this is by no means a common form of construction, though we find instances here and there, of which Spirotænia condensata, Plate XIII., fig 60, is an example.

The decayed remains of Sphagnum in peat bogs are often rich with the empty frustules, well adapted for examination, though, from their dirty brown colour, and from being mingled with the surrounding vegetable matter, they are not fit specimens for the herbarium. Having lost the bright green of the living Desmid, they are difficult to distinguish with the naked eye; in fact, they are mere empty cases; but none the less welcome to the collector on that account, as they often give him opportunities of studying the cell membrane, which he cannot get with specimens better adapted for preservation. And here let me recommend him to be always provided with plenty of phials on his excursions, that each gathering may be kept apart; otherwise he entails upon himself a vast amount of trouble, when he comes to separate the species for preparation.

Many of the Desmidiaceæ will readily propagate when kept in a room in a sufficient quantity of bog-water, thus enabling one to get an abundant supply of clean specimens. The plate, or saucer, in which they are placed, should be covered with a sheet of glass to keep out the dust, and to prevent the water from evaporating too rapidly. However, should the water get too low from this or any other cause, the supply must be made up with rain or soft water, on no

account with that from a spring, as its 'hard' property is sure to kill the plants. Care must be taken also not to expose the vessel to too much heat; in fact, it had better be set in the shady part of a window, where it is screened from the direct rays of the sun.

The student must not expect too much from this method of multiplying the Desmids. It does well for a while; but there is no doubt that, in the course of time, the plants degenerate, and cease to be fair representatives of the species.

[The figures (61 to 70) on Plate XIII. will give the young student an idea of the manner in which the Desmids propagate themselves. They are examples of the common constricted species, Cosmarium botrytis.

In figs. 61 to 64 we see how the two portions of the frustule gradually separate themselves, new cells forming in the interior, which ultimately become perfect frustules. This mode of propagation is known as 'cell division.' By another method, called 'conjugation' (of which more will be said hereafter), two frustules, which chance to lie near each other, form a temporary union, and mingle their contents together, figs. 66 to 69. The mass takes an irregular form at first, but gradually assumes the shape given in fig. 70, viz. a globe covered with forked processes (*a*, *b*). This globe, or sporangium, as it is named, gives birth to new plants —ED.]

Where the observer is content to study the external form only, the plan of simply drying his specimens on a slip of glass is sufficient; because, on re-moistening them, the plants resume their former appearance. If, on the other hand, he wishes to examine the peculiar arrangement of the Chlorophyll), and the other contents of the cell, after the object has been laid by, he must preserve them in some fluid which will not alter their natural form and structure. Much time also is saved by his having such preparations ready to hand for comparison and observation. Moreover, many of the smaller Confervæ (such as Zygnema and

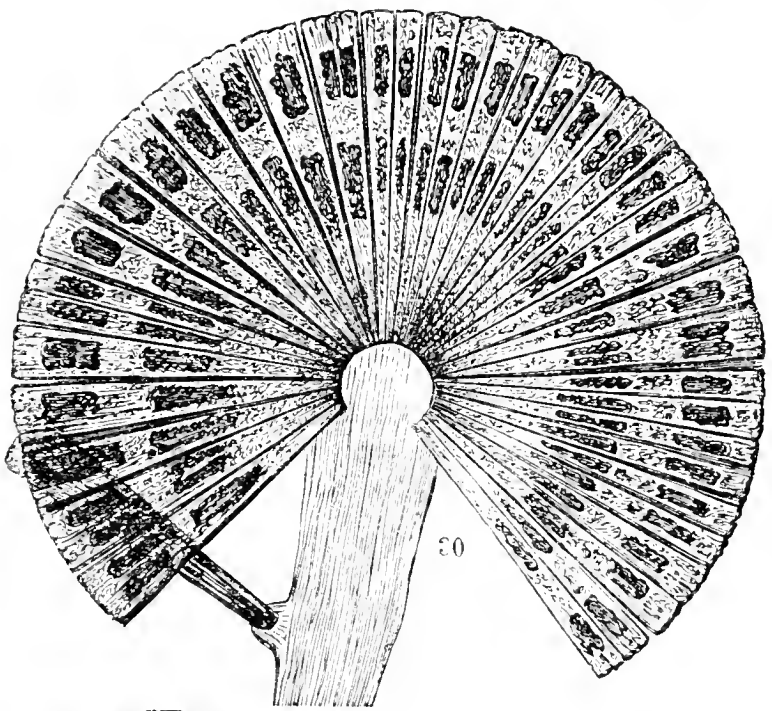
Spirogyra), whose characters depend entirely on the arrangement of the cell contents, are destroyed in the act of drying, their structure is utterly lost, and no soaking in water will ever restore them. It happens too, sometimes, that we have only a poor supply of some rare species, which gradually disappears under too frequent examinations, and its possessor would gladly preserve the remainder once and for all.

Influenced by these considerations, physiologists have applied themselves, from time to time, to the discovery of some method by which these minute and delicate organisms may be kept unchanged for a lengthened period; but it must be confessed, with less success than their industry has merited.

The great want which has marred all their efforts has been a fitting medium; or, in other words, a fluid of such a nature that the plant, when immersed in it, shall not become distorted, or indeed receive any appreciable change for a long lapse of years, provided the cement enclosing it retains its air-tight properties. The want of success, it must be allowed, has not arisen from the positive evaporation of the liquids employed (glycerine, chloride of calcium, &c. retain their density for a very long time), but from the method of employing them. Following a natural law, the frustule, immediately upon being enclosed in its cell, begins to part with the water contained within itself. And what is the consequence? The surrounding medium cannot take the place of the water, the primordial utricle* contracts, the contents of the cell collapse, and the plant is left as much changed and disfigured as though it had been originally dried.

The botanical world is, therefore, greatly indebted to Herr Hantzsch, of Dresden, for his researches in this direction, which have resulted in discovering an arrangement

* The primordial utricle (*primordial Schlauch* of the Germans), is the name given by Mohl to the delicate membrane which lines the inner cell wall, and which encloses the protoplasm, or viscid fluid, with granules intermixed, which forms the contents of the cell.—Ed.



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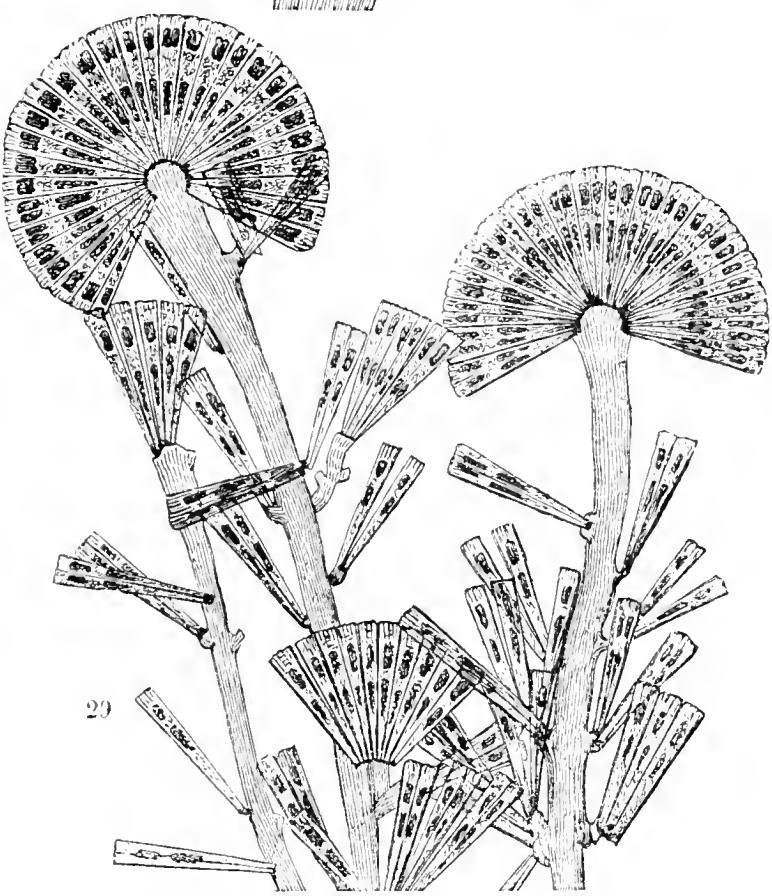

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29. Licmophora flabellata.

30. Fan of Licmophora.

which completely supersedes the various unsatisfactory plans hitherto adopted.

His method differs from all others in this, that he advocates a gradual, not a sudden, application of the preservative fluid, so that the action of endosmose may be in some measure retarded, the adjustment of the difference of density within and without the vegetable cell carried on more slowly, and the consequent preservation of its delicate structure ensured. For this purpose he recommends the following composition:—3 parts of alcohol (as pure as possible), 2 parts of distilled water, and 1 part of glycerine. The specific gravity of this mixture being nearly the same as that of water, it does not tend to contract the primordial utricle. Now, if the water and the alcohol be allowed to evaporate slowly, the mixture will of course become proportionally denser, but quite gradually, and therefore without any destructive influence on the object. During this operation, the water is withdrawn from the frustule, and the glycerine, which is not volatile, takes its place, without causing any distortion whatever in the plant.

To make a preparation, the Algæ should be laid on an ordinary slide, on which a ring* of the requisite size has been previously drawn with asphalt, the latter being allowed to dry quite hard before being used. To make assurance doubly sure, a drop of distilled water may be laid on the frustule, and then a drop of Hantzsch's fluid. Should the latter, on examining the specimen, appear to be acting too rapidly, water must be added to thin it. With regard to this part of the operation it is impossible to lay down specific rules, because the Algæ, though all very

* These rings (if round) may be easily and quickly made, and the cement afterwards applied by means of a Shadbolt's turn-table. Square spaces may be enclosed of equal size on any number of slides by drawing a square of the required size on a card, placing the slide over it, and painting it with cement.—Ed.

sensitive to endosmose and exosmose, are so in different degrees.

The slide must now be laid aside for awhile, covered with a bell glass, wine glass, or something of the kind, to keep off the dust, while the volatile portion of the mixture is evaporating. On its being ascertained that the glycerine alone remains, another drop of the liquid is to be applied, and a second evaporation submitted to; and so, again and again, until there is enough of the pure glycerine present to fill the greater part, though not the whole, of the ring. The time has now arrived for covering the object with thin glass. Let a piece of suitable size be selected—the thinner the better; if it be too thick, the chance of rendering the cell air-tight is lessened; besides, a thick covering glass precludes the use of the highest powers of the microscope. Care must be taken to clean it thoroughly, just before laying it on, by washing in alcohol or dilute liquor potassæ, and drying with a soft cloth and leather. Nor must it again be touched with the fingers, otherwise, at every point of contact, a mark is left, to which the cement adheres with difficulty.

The operator now seizes the thin glass cover with pincers, lays a narrow strip of asphalt cement on one of its edges, for about one-third of its circumference, and lays it, cement downwards, on the object. The glycerine forthwith spreads out, and occupies the enclosed space. A gentle pressure with the end of the pincers tends to fix the cover in its place, and to force out all superfluous liquid, which must be absorbed to the last atom by blotting paper, or a soft cotton cloth. The best way (though of course nothing but long practice can ensure it) is to apply, in the first instance, only so much glycerine as will fill the shallow cell without overflowing.

The slide must now be put away without being touched for twenty-four hours, at the end of which time the strip of cement will have dried, and will hold the glass cover in its place. The work may, therefore, be proceeded with. The

first great need now is to see that not a trace of glycerine remains outside the ring enclosing the object. Should there be any, it must be removed thoroughly before any further steps are taken. If satisfied that the glass is quite clean, a line of asphalt must be drawn with a soft hair pencil round the whole edge of the cover, so as to include it and its place of contact with the slide. It must be done slowly, and the slide watched, to see that no bubbles of air, or any foreign bodies, are enclosed within the circle. This layer of cement having dried, a second, third, and even fourth may be added, until the preparation may be reasonably supposed to be air-tight. This may be most readily tested by holding the slide between the eye and the light, and seeing whether any part covered by the cement is transparent, especially the corners, if the covering glass is square. Any semi-transparent spot, or line, must be repainted with cement. The cement, it may be added, should be very thin when in use. It is then laid on much more easily, and tends to make the preparation more truly air-tight. A thick cement dries badly, and is apt to crack and chip off, especially during changes of temperature.

The preparation may now be considered complete. The name and other particulars will of course be added, and it may, if desired, be covered with ornamental paper. One most necessary point must not be forgotten, that is, under all circumstances, to lay the slide in a horizontal position. If set upright, the contents flow to one side, get heaped together, and eventually the fluid is almost sure, by its weight, to force its way through the cement, and cause a fatal leakage.

[Since the above was in type, I have had the opportunity of examining slides of Desmidiaceæ, prepared in Dresden after Herr Hantzsch's method. Nothing can exceed the beauty of these preparations; the form of the plant and the colouring of the endochrome having undergone no change whatever.—Ed.]

As to the characters most worthy of observation, nearly

the same remarks as were made on the Diatomaceæ will apply to the Desmids. In this case, also, both a front and side view should be obtained, in order to get a satisfactory knowledge of their form. Their markings differ essentially from those of the Diatomaceæ; in the latter, they are almost invariably depressions; whereas, in the present order, they consist of elevations, warty and spinous processes. They may be seen best in examples mounted dry, especially in such species as appear smooth and plane, when immersed in a fluid. The chances are, that on drying these, some markings will become visible, as also in the case of their silicious relatives. Oblique illumination will often bring out fine points, which are not to be seen by direct light.

If, as not unfrequently happens, one has a single gathering only, and that a poor one, of some rare Desmid, it is better not to wet the specimens, as they lie on the slip of glass, but simply to breathe on them, and then cover them with thin glass. The plants will imbibe sufficient moisture to swell out, or at least assume as much of their original form as is necessary for examination. On removing the cover, they will again dry up, and may be replaced in the herbarium. In this way none of the precious material is lost, as would be the case if it was constantly soaked in water. The object, it is well to remember, must not be placed under the microscope while uncovered, otherwise the moisture rises by evaporation, and quickly dims the lenses.

The student is recommended not to neglect making drawings of the most prominent characters observed by him. He will find them most useful afterwards for the permanent preservation of some of the nicer shadings of the markings on the outer membrane, and for comparison with the figures given in works devoted to the subject. It need scarcely be added that, in choosing specimens from which to make his drawings, he should take care to select as perfect examples of the species as he can find. There is no

family in the whole range of the plant world which presents such a boundless variety of forms, and consequently none in which mistakes and confusion may more easily arise from neglect of this precaution.

There are certain minute Algæ (of which Aphanizomenon is an example), members of the Confervoid order, which float on the surface of the water, forming a delicate mucous film. These may be most conveniently secured by scooping them up with the tin ladle described at p. 4, and pouring them into a linen net. As the water passes away, the Algæ are left behind, and as soon as a sufficient quantity is obtained, they may be scraped off into a bottle, to be conveyed home.

The specimens of Aphanizomenon should be mounted as speedily as possible (it is best done on the spot), because the faggot-like bundles of filaments quickly separate and fall asunder. If it is desired to retain the true habit of the plant, it ought to be caught at once on paper, and allowed to dry without delay. By exposing the dried specimens for some days to the light and air, the yellowish colour which they possessed during life passes into a brilliant green tint.

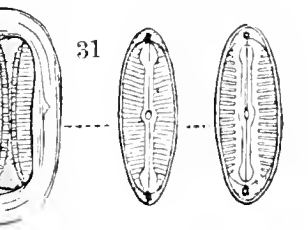
[Though scarcely to be reckoned among 'collectors' plants,' I cannot omit mention of the Volvocineæ among the minute Algæ placed, for convenience sake, in this chapter. Their singular motions—for most of them move freely through the water with the aid of cilia—their peculiar forms, and wonderful modes of propagation, render them objects of great interest to the microscopist. The figures in Plate XIV. represent two well-established genera of this group of plants.—Ed.]

CHAPTER VII.

OF THE FILAMENTOUS ALGÆ.

Although there are many more filamentous Algæ than those indicated below, yet for the purposes of the collector we prefer to group together only the families of Confervaceæ, Zygnemaceæ, and Œdogoniaceæ. All these, with few exceptions, inhabit the same localities; in many respects are very similar to each other; and are prepared for the herbarium in the same way. To these may be added also the genera Batrachospermum, Ulothrix (a portion only), Vaucheria, Hydrodictyon, Calothrix, Tolypothrix, and Hydrurus.

Almost all the members of this group are partial to standing water, swamps, bog-holes, and lilliputian bays, in streams and ponds. The species of Zygnema are found in clear cold springs, which they sometimes fill with their glossy green tufts. On the other hand, Cladophora, Ulothrix, and Vaucheria take up their abode in rivulets and watercourses, where they attach themselves to stones and other fixed objects, and thus safely anchored, let their long wavy filaments follow each motion of the stream. For specimens of Zygogonium, Hormidium, Schizogonium, Chroolepus, and some of the Vaucheriæ, the collector must search, not the water, but the land-damp stones and muddy ground, so that in their mode of life they are exceptions to the great bulk of the filamentous Algæ: as are also the genera Chantransia, Microthamnium, Gongrosira, Chlorotylium, Coleochæte, and Chætophora, which, on account of their habit of forming close matted strata, must be excluded from our 'filamentous group,' and be treated of elsewhere.



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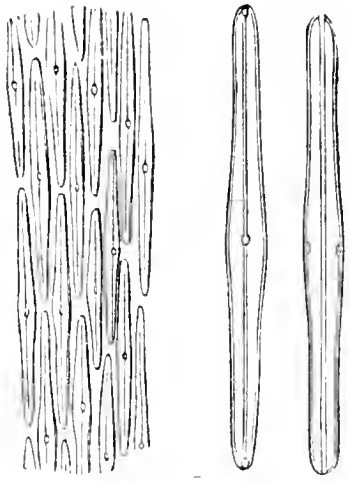

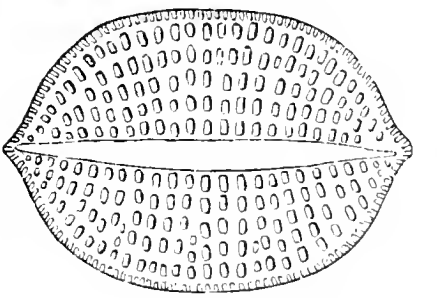

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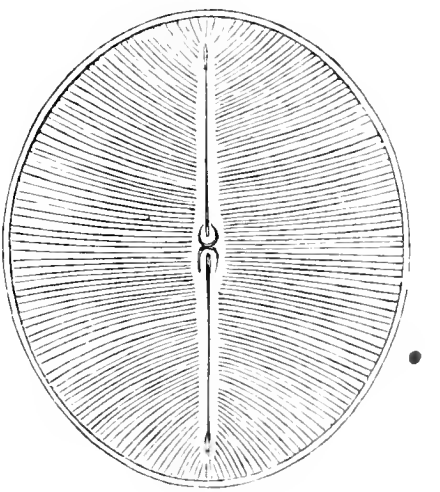

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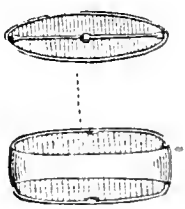

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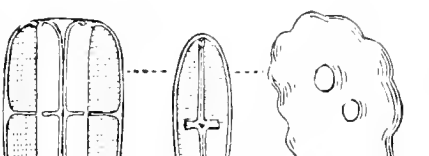

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31. Mastogloia Danseii.
32. Dickieia ulvoides.
33. Dickieia pinnata.
34. Berkeleya fragilis.
38. Cocconeis major.
39. Cocconeis nitida.

Those species which inhabit stagnant water throw out numerous filaments, which becoming more or less entangled and interwoven, cling together in cottony tufts. The generality of these, when quite young (Spirogyra, for instance) form a thick layer at the bottom of the water, or at any rate float at some depth below the surface. At a later season, however, when the plant is preparing for fructification, or when, in consequence of its active vegetative powers, a large amount of oxygen is generated, then the plant rises to the top of the water, and covers a wide space with its outspread filaments.

To collect these species, the only instrument necessary is the toothed ladle, attached to a walking-stick. By means of this any quantity of the weed may be fished out, by simply moving the stick from right to left, the filaments catching in the teeth of the ladle and being retained there.

When the Alga lies near the bank, it can, of course, be gathered with the hand. If, on the contrary, its masses float a long distance off, too far to be reached by the stick, another plan must be resorted to. This simply consists in removing the wooden handle and then tying the ladle to a piece of string of sufficient length. The ladle may now be thrown among the weeds, and on being drawn in some of them are almost sure to be clinging to it. The plan may not be successful at first, but I have invariably found that perseverance will bring success. Even at long distances and in deep waters I have rarely been disappointed of the coveted treasures.

Let the water drain off before the specimen is put away in oilskin, and the draining may be aided by a gentle pressure of the hand; but the collector must be careful not to squeeze it too hard, for if he does he will lose what Diatomaceæ may be entangled in it; and, besides, the Alga itself soon dies and corrupts when robbed of its natural element.

A pleasing contrast to these entangled masses are the graceful feathery plumes which distinguish the species

inhabiting quickly-flowing streams. In most cases (especially with the species of Cladophora) the plant must be gathered as near the point of attachment as possible—the point, that is, corresponding to the root in a flowering plant; for, since the determination of the species depends in great measure on the position of the main stem, its degree of ramification, &c., it is by no means a matter of indifference whether the whole plant or a mere fragment be secured. This precaution is not so necessary with the Ulothricaceæ, as they consist of unbranched filaments. On that very account they should be carefully collected with the hand, not with the ladle, and then laid lengthways on a strip of paper so as not to disturb the filaments, which adhere but loosely together, and are easily separated and carried away by the draining off of the water.

If the tufts (as is often the case with the Vaucheriæ) are dirty and discoloured, the mud and sand must of course be washed off before the specimens are prepared for the herbarium. They had better, however, be carried home first, and thoroughly examined for Diatomaceæ. It will be time enough then to cleanse away impurities, taking pains during the operation to avoid entangling the filaments, and to preserve the natural habit of the plant.

All the filamentous Algæ may be laid out for ultimate preservation on stout writing paper. The size of the paper may be proportioned to the length of the object to be laid on it. In practice, however, I have found the most convenient form to be as follows: Let a half sheet of writing paper be cut longitudinally into three strips, and let each of these be again divided across the centre. A sheet of paper will then give twelve portions, each of which is of such a size as to lie comfortably on the palm of the hand. The plants having been well cleaned from fallen leaves, twigs, decayed matter, &c., and divided into several distinct portions, are allowed to spread themselves out on the surface of water in a large dish. One of the portions is now taken out and made to float in another

vessel—a hand-basin is perhaps the best thing: at any rate, the vessel must be of such a depth as to admit of the whole hand being immersed, back downwards, under the plant. Give a final touch to the specimen either with a needle or with the fingers, to induce it to spread its filaments in every direction equally, and to get rid of knots and lumps. Then draw the piece of paper carefully under the specimen, so that the latter floats immediately over the centre. Spread the left hand under the paper, and the whole can be lifted slowly and cautiously out of the water. It may be retained for a few seconds in this position to let some of the moisture drip off, and then laid just as it is on a packet of five or six sheets of blotting paper.* In this way the whole of the specimens at hand may be gradually disposed of. The next step is to place them under the press. For this purpose the little heaps of blotting paper, each with its accompanying specimen, are to be piled one above the other to any convenient height, a sheet of stearine paper having been laid on each specimen before it receives its load of drying paper. The layers then follow each other in this fashion: 1. A packet of blotting paper; 2. A specimen on white paper; 3. A sheet of stearine paper; 4. A packet of blotting paper; and so on, the uppermost layer always consisting of blotting paper. The whole pile is next to be laid between two smooth boards of well-seasoned wood. [If to each of the narrow ends there is attached a broad strip of the same wood, but with the grain running in the opposite direction to that on the board itself, it tends greatly to keep it from warping, which the alternations of heat and moisture are apt to induce. Much has been said of late years of the advantage of using, not solid boards, but frames made of parallel strips of wood, one inch apart, held together by

* The blotting paper should be white, free from knots and roughnesses, and as absorbent as possible.

cross bars. I mention the plan, but have had no experience of it.—Ed.]

The plants are then to be subjected to the pressure of three or four bricks. I consider bricks to be preferable to stones or iron weights, on account of the handiness of their form and the ease with which the pressure may be regulated. For cleanliness sake they should be wrapped in paper or linen; it is advisable also to sling them by cross pieces of string with a loop in the centre.

Many botanists prefer an ordinary linen press to any of these things, but such an apparatus is not always to be found when wanted.

[Others again give the preference to a form of press, such as is represented at fig. 82, Plate xv.

As the reader will observe, cross-beams of wood enclose the boards used for drying, and are held together by four upright iron rods. The requisite degree of pressure is given by tightening or loosening the screws, which are placed at the top of the rods.—Ed.]

After about twenty-four hours the preparations may be examined, and in case they are not dry, must have the blotting paper changed, and be again placed under pressure. A week will frequently elapse before the plants are fit to be put away in the herbarium. It is the nature of almost all Algæ, when they are drying, to cling closely to the paper on which they lie, and the use of the stearine paper is to prevent this from taking place during the time the plants are being pressed. In my opinion, it is far better for the purpose than oiled paper, which was much in vogue at one time, as the latter is apt to leave spots and marks on the white paper to which the specimens are attached. Now, stearine does not sully the objects with which it comes in contact; and as the material itself is cheap and easily prepared, it is much to be preferred to paper impregnated with either oil or wax.

To get it ready for use, let fragments of a stearine candle be rasped into shreds and strewn equally over a sheet of

white blotting or printing paper. Cover this with a second sheet, which is to be also strewn with stearine chips; and so on, until five or six alternate layers of stearine and paper have been deposited. Next, let a hot iron be passed over the whole; the stearine melts, and, forcing its way among the fibres, renders the paper partially water-tight. No attempt must be made to separate the sheets until the stearine is cold and hard, otherwise they will cling together and be spoilt.

Where it is requisite to prepare large quantities of the paper at one operation, the heap, instead of being ironed by hand, may be placed on a tin plate in the oven, or immediately in front of the fire.

After being used for some time, the stearine paper (especially if the Algæ with which it comes in contact are wet and succulent) becomes more or less opaque, and the plants are apt to cling to it. When this is seen to be the case, all that is necessary is to pass a hot iron over it, and the sheet is restored to its former condition.*

In preparing this class of Algæ for the herbarium, no special attention need be paid to peculiarities in the growth of such as are found in thick heavy masses. On the other hand, the habit of those which grow in long flowing tresses must be carefully observed and retained. These last represent, to a certain extent, the higher plants, from the root to the apex, and must be treated accordingly. Care must be taken, as I mentioned just now, to get a specimen direct from its point of attachment to the stones or other object on which it had passed its existence, and to carry it home without bending or entangling its filaments. If this precaution has been attended to, the tiny branches, on

* The Rev. D. Landsborough, in his 'Popular History of British Seaweeds,' recommends a fold of muslin to be laid over the specimen. He adds, however, 'In shifting the specimens the second time, the muslin coverings may be removed. When permitted to remain till the plants are quite dry, there is danger of their leaving chequered impressions on the specimens.'—Ed.

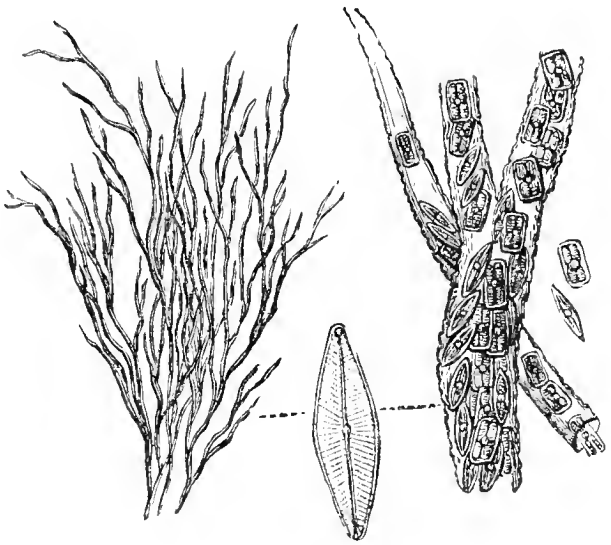
being placed in a vessel of water, will spread themselves out; and in this they may be assisted by passing a needle several times through their entire length from base to tip. Let the paper be raised very slowly through the water on the left hand, while the root end of the plant is held firmly with the right. If the paper be slightly shaken, the filaments will expand themselves still more fully, and will be prevented from rolling into a thick cord-like tuft along the middle of the paper, as so often happens when the hand is raised too suddenly from the water.

Auerswald recommends a thin metal plate in lieu of the hand for lifting the plants from the basin. As regards the smaller specimens, my own experience is not in favour of this plan, because one can regulate the draining off of the water so much more easily with the fingers than with any mechanical appliance. With the larger Algæ, on the contrary, I have found it an admirable method, as the flatness of the plate prevents the paper from falling into folds and wrinkles. If a metal plate is not at hand, the cover of a cigar-box or any thin flat piece of wood makes an excellent substitute.

The fronds of Draparnaldia and Stigeoclonium (it is well to bear in mind) are too delicate to allow of their being subjected to the press. Their filaments, after being removed from the water, may be still further arranged by the aid of a needle and hair pencil, and then the specimen should be put on one side to dry.

Some species of Cladophora, which grow to a great length, cannot be laid on paper of a manageable size. It is best in this case to give the plant a serpentine motion as it is being lifted from the water. It can thus be laid without difficulty along the edge of the sheet in an undulating manner, then covered with the stearine paper, and pressed as usual. In this way, at least one preparation may be made, which comes within the compass of a sheet of paper, and yet represents fairly the natural habit of the plant.

The Zygnemaceæ, as previously mentioned, cannot be



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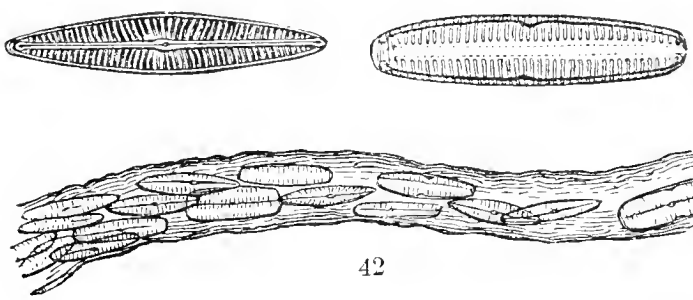

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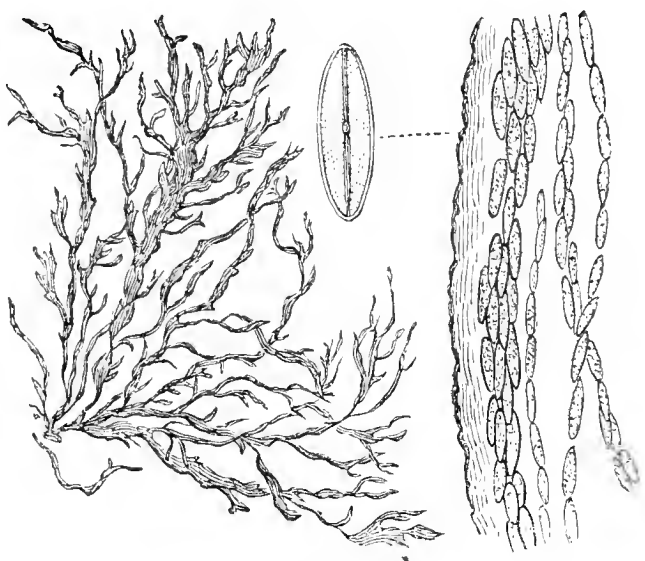

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40. Schizonema Grevillei. 41. Micromega helminthosum.
42. Colletonema neglectum.

treated like the rest of the filamentous Algæ, because their peculiar cell contents fall together and are lost during the process of drying, nor can they be restored by moistening them. These elegant Algæ, therefore, must be preserved by Hantzsch's method. If, however, the student wishes to have some specimens in a dried condition, they must be treated in the way recommended for the most delicate of this class of Algæ. There is a circumstance, however, to which I would call attention, because it is often looked upon as the commencement of a failure. It is, that these plants, during the process of drying, invariably lose the rich green which distinguishes them in life, and become of a brown or black colour, nor does the green ever return. It is a curious fact, moreover, that the portion of paper on which they have lain assumes a yellow tint on being soaked in water.

With regard to searching for the filamentous Algæ, a few suggestions remain to be offered.

The different Vaucheriæ, Zygnemaceæ, and Œdogoniaceæ can be determined only when in fruit; it is useless to gather them at other times. The ripening of the spores is usually accompanied with the development of an oily matter, having a brown or reddish tint, which frequently gives a very pretty appearance to the plants. The red colouring so often seen in Sphœroplea arises from this cause, the ripe spores filling the cells in immense quantities.

The Zygnemaceæ at some periods of the year are found in what is termed a state of 'conjugation'— that is to say, two filaments lying parallel to each other throw out processes by which they become united together. The cell contents of one filament are then discharged into the other filament, and eventually become spores. Examples of this singular mode of propagation are given in Plates XIII. (figs. 66 to 69), XV. (figs. 83 to 85). To find filaments of this description search must be made beneath the floating masses. They may be distinguished as well by their light yellow colour as by the fact of their having a slighter cohesion

than is the case with the greener and more compact portions of the tuft. Specimens of the conjugating filaments should always be obtained, if possible, as the characters of several of the genera are based upon this curious phenomenon. I may mention among others Mougeotia, Mesocarpus, Pleurocarpus, Craterospermum, Staurospermum, Rhynconema, and Spirogyra. In all these the sterile filaments are of little service in affording generic characters, whereas (except in the one mentioned last) the presence of conjugating examples marks the genera at once, even after they are dried.

Another remarkable phenomenon, the so-called 'Swarming Spores,'* common to all the filamentous Algæ, is most easily observed in the species of Ulothrix. The escape of the Zoospores from the parent cell generally takes place in the early part of the day, and betrays itself even to the naked eye by a green film which forms on the water's edge when the Algæ are kept in a glass vessel. It may be observed, too, in the Œdogoniaceæ, especially in Œdogonium fonticola, in which the swarming spores may be seen at almost any period of the year. The cilia with which these spores are furnished defy detection on account of the almost incredible swiftness of their movements; but they may be seen easily enough if a drop of solution of iodine† be allowed to work its way by capillary attraction under the covering glass. As the solution mixes with the water, it paralyses and finally kills every object of an organic nature with which it comes in contact. While this is taking place, the observer must keep his eye fixed upon the dying spores, applying a rather oblique—at any rate not too bright—illumination, and then he will see the glistening threads as they swing to and fro.

Many of the Cladophoræ, Confervæ, and Œdogoniæ,

* It takes its name from a fancied similarity of the movements of the Zoospores in the parent cells to the swarming of bees.—Ed.

† Either iodine dissolved in alcohol, or an aqueous solution of iodide of potassium.

exhibit a peculiarity in the contraction of their cell walls when they are drying; that is to say, the latter do not return to their former state when soaked in pure water; but if a little muriatic acid or caustic potash be added to it, the cells immediately swell out to their original form. Should the filaments be encrusted with crystals of lime, they may generally be got rid of by means of dilute muriatic acid.

There is one genus, Psichochorium, which has the remarkable property of depositing lime in the joints of its filaments. Special care must be taken to get rid of this when the specimens are being prepared, as, in case of their being left behind, the very parts become obscured and useless on which the generic characters depend.

CHAPTER VIII.

OF THE OSCILLATORIÆ.

Of the members of this family, the Lyngbyæ and the species of Leptothrix which float on the surface of the water may all be prepared in precisely the same way as was recommended for the Confervæ in the previous chapter. Those like Phormidium, which form filmy masses, will be treated of presently. But the genus Oscillatoria itself requires a peculiar mode of preparation. The individuals embraced in this group dwell by preference on mud at the bottom of shallow ponds and ditches; though frequently, on a sudden rise of the water, they break away from the soil and float, appearing like a cloudy film radiating from a centre. All have a disagreeable odour, which clings to them long after they have been deposited in the herbarium. They vary much in colour; the common tint is an æruginous green, darker or lighter in different species. Others are steel-blue or even brown—as, for instance, Oscillatoria Fröhlichii in many of its habitats. During the process of drying, they change colour, owing to the influence of the oxygen in the atmosphere, their tints gradually becoming brighter and more intense. This is well seen in the last-named species, which is usually of a deep brown during life, but which after death, and while drying, assumes first a blackish-green tint, and then a steel colour.

The family takes its name from a property peculiar to some of them, but not common to all, of spontaneously oscillating or waving gently backwards and forwards, like a very slow-moving pendulum. To whatever cause this mysterious movement may be due, the fact itself is of

essential service to the collector, who is enabled by it to secure perfectly pure specimens for preservation. As stated above, the members of this family delight to dwell on the mud, nor can they be got out without a plentiful supply of the latter. But this is of little consequence. Mud and plants may be thrown together into a vial, and on being brought home may be poured out into a deep dish with a sufficient quantity of soft water, and then left undisturbed near a window. The active little organisms immediately set themselves in motion, and creep out from among the earthy particles by which they are encompassed, forming by degrees a pure thin layer on the surface of the water, whence they may be taken up with a spoon, in larger or smaller quantities, at the will of the operator.

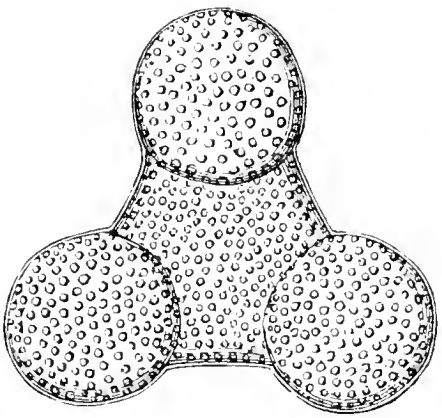
Next, for the best method of preparing them for the herbarium. This also is made to depend on the movements of these singular plants. First, let a sheet of stout paper—drawing paper is the best—be provided, and on it describe, with pencil and ruler, about eight squares of equal size. Fix the paper firmly on a wooden board with needles or artists' pins, and lay in the centre of each square a small quantity of *soft* water.* Let the water spread over a circular space the size of half a crown, and then add a few drops carefully so as to raise the centre as high as possible. By this means the final evaporation of the water is retarded to the utmost. Having thus prepared the paper, the next step is to deposit in each square a quantity of the Algæ, taking care to choose portions least contaminated by mud—a piece about the size of a bean is sufficiently large. Separate the filaments by a gentle touch of the finger, and let the whole be left in a spot well exposed to the light. Before very long (the time depends a good deal on the season of the year, the freshness of the plants, the amount

* The use of 'soft' water is insisted on, because the vitality of the Oscillatoriæ is quickly destroyed in hard spring water, and the success of these experiments depends entirely on their vegetative principle being strong and active.

of light, &c.), the operator will observe, even without a lens, a dark filmy mass radiating from the common centre of each piece of water, and spreading equally over the surface. Gradually the edges are reached, and then the filaments bend themselves round, and follow the line of the circumference. To make really good preparations, the greatest pains must be taken not to jolt or shake the paper until the water is entirely dried up, and the Algæ lie flat on the spot prepared for them. As soon as this has taken place, the sheet should be removed from the board, and divided into the several parts marked off by the pencil. Each of the examples is then ready to be deposited in the herbarium.

The reason why it is advisable to prepare several specimens on a single sheet, and to fix the latter to a board during the operation, is, that the Oscillatoriæ are of an exceedingly fragile nature, the filaments easily falling to pieces, and the fragments jerking themselves off the paper, if the latter be crumpled and then suddenly bent straight again, as is sure to happen when it is laid in the herbarium. Now, small pieces of paper do get so crumpled, while they are drying, in consequence of being acted on unequally by the water: whereas large sheets accommodate themselves more readily to the contraction and expansion caused by evaporation; and consequently the individual sections are smoother and less wrinkled when the whole is cut up. A single experiment will demonstrate this.

There are certain genera, some of which belong to the Oscillatorian family, the members of which (instead of spreading themselves out like those we have just been speaking of) group themselves into close flocculent masses. Such are Phormidium, Microcoleus, some species of Symploca, and not a few of the Scytonemaceæ; among the Ulotrichæ, Hormidium and Schizogonium; and of the Zygnemaceæ, Zygogonium. In all these forms the filaments have a tendency to develop themselves towards the interior, and their growth is exceedingly complicated in



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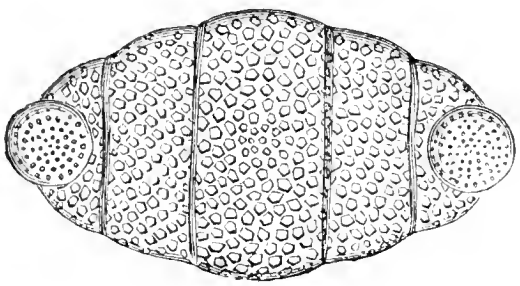

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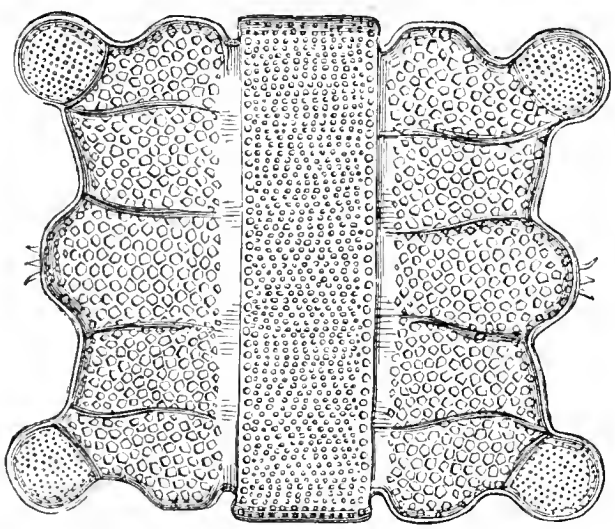


46. Biddulphia pulchella.

47. Triceratium castellatum.

consequence, so that they form compact webs or films, and can be gathered up in closely combined masses. They are found upon damp earth, wet rocks, palings, and tree stems.

Their treatment is of the simplest kind. The collector has only to peel the film off the earth or stone, and lay it between the leaves of an old book in order that it may not get wrinkled or bent. If too dry, the specimens had better be moistened before being laid in the book, to prevent their breaking. On reaching home, they may be pressed between sheets of blotting paper, and when quite dry, and without any tendency to curl up, may be laid on a sheet of paper with the lower side gummed down, and so put away in the herbarium.

CHAPTER IX.

OF THE GELATINOUS, CRUSTACEOUS, AND STONE-LIKE ALGÆ.

We find among the Algæ a considerable group in which the external membrane possesses the peculiar property of surrounding itself with a gelatinous substance, varying in its consistency in the different species: and in this mucous matter the inner cell (or Gonidium of Kützing) lies embedded. As the cells continue to multiply, colonies are raised (larger or smaller according to the amount of division in the original cell), forming masses which are generally amorphous, though sometimes of a definite outline, and then usually spherical. In this way arise the soft gelatinous layers of a portion of the Rivulariaceæ and Chætophoraceæ, a kind of slimy matter holding together the individual filaments.

Such species may be looked for in marshy stagnant pieces of water, on damp earth and the surface of wet rocks, where they form a smooth jelly-like coating. The species found in water usually commence their existence on stones or attached to water-plants, from which they eventually separate themselves and then float on the surface. When this is the case, they are to be collected by means of the 'tea-sieve,' and from thence transferred to a wide-mouthed bottle; while those that are adherent must be taken up together with the object on which they rest. If growing on rocks, they may be scraped off. No special preparation is needed. The gelatinous substance may be divided into any convenient number of portions, and dried upon paper. When thoroughly damped at a future period, the masses will swell out to very nearly

their former consistency, even after they have been laid by for a considerable time.

Those species of Nostoc which are of a coarse dense consistency, becoming corrugated when dry, may be covered with stearine paper and placed under a light pressure.

Many of the Algæ again are furnished with crustaceous or foliaceous fronds, firmly fixed to some underlying substance. Of this description are most of the Scytonemaceæ, the genera Hydrococcus, Schizosiphon, Chroolepus, Protoderma, Chlorotylium, Coleochæte, Gongrosira, Hildenbrandtia, Melobesia, and several others. Some of these (as the Scytonemaceæ and Chroolepus) form compact felt-like layers on wet shady rocks and walls, or on the bark of trees. Others (as Hildenbrandtia) are found encrusting stones and pebbles, spreading irregularly over the surface, and have a wrinkled leathery appearance. Finally, Hydrococcus, Chlorotylium, and some others, form tiny sponge-like excrescences, which at length unite into a mass of rough uneven knobs. Some of the smaller kinds (Coleochæte, Melobesia, &c.) are parasitic on the larger Algæ, and such water-plants as Sedges, Mosses, and Potamogeton, where they often flourish in the greatest abundance, though frequently overlooked, as many of them—the species of Coleochæte, for instance—are too minute to be easily detected by the naked eye.

As it is always desirable to secure specimens that give a clear conception of their mode of growth, the plants should not be rubbed or scraped off, but gathered with the object on which they are growing. Where the species are at all abundant, small stones are sure to be found clothed with the membranous crust peculiar to these Algæ; these may be taken and put away just as they are. In the case of such as occur upon trees (the Chroolepi, for instance), they may be obtained without injury by cutting off a portion of the bark. They are more difficult to get at when growing on the face of a rock or large block of

stone; here a stout hammer and two good steel chisels are requisite—one of the latter being broad and flat, the other pointed. The former serves to break off a piece of rock of the required size, when the plant grows on an angle, or at least where there is a good bearing for the instrument; when, on the other hand, the surface is smooth, and offers no point of resistance, the narrow-pointed chisel comes into play to punch out a notch, on which one side of the broad chisel may rest, while a smart blow of the hammer is given. Of course, the thinner the stony bed of the Alga is, the better, as then it may be deposited among the leaves of the herbarium; whereas if it be too thick it must be kept in a separate drawer or cabinet. Let me here warn the young botanist to fold the sections of rock or bark each in its own piece of paper, before placing them in his pocket or bag, to prevent the specimens from being rolled and rubbed together: unless this precaution be taken, the adherent Alga is certain to be much injured, if not entirely destroyed. If the stones, on being brought home, are found to be sufficiently thin and flat, they may be gummed on stiff strong paper; and so with the pieces of bark. Should they be too large and rough, they may be put away on the shelf or in the drawer of a cabinet, such as is used for mineralogical collections.

Vegetable parasites like Coleochæte may be dried and put away in paper bags; or, if it is thought worth while to take so much trouble, may be stripped from their bed, and either dried upon glass or mounted in Hantzsch's fluid.

Some of the foregoing species are encrusted with lime. These must be immersed in dilute muriatic acid, in order to get rid of the lime, before they can be properly examined. The operator must recollect not to lay on the cover until the bubbles of carbonic acid have ceased to rise; otherwise they will collect under the glass, and the experiment will come to nothing.

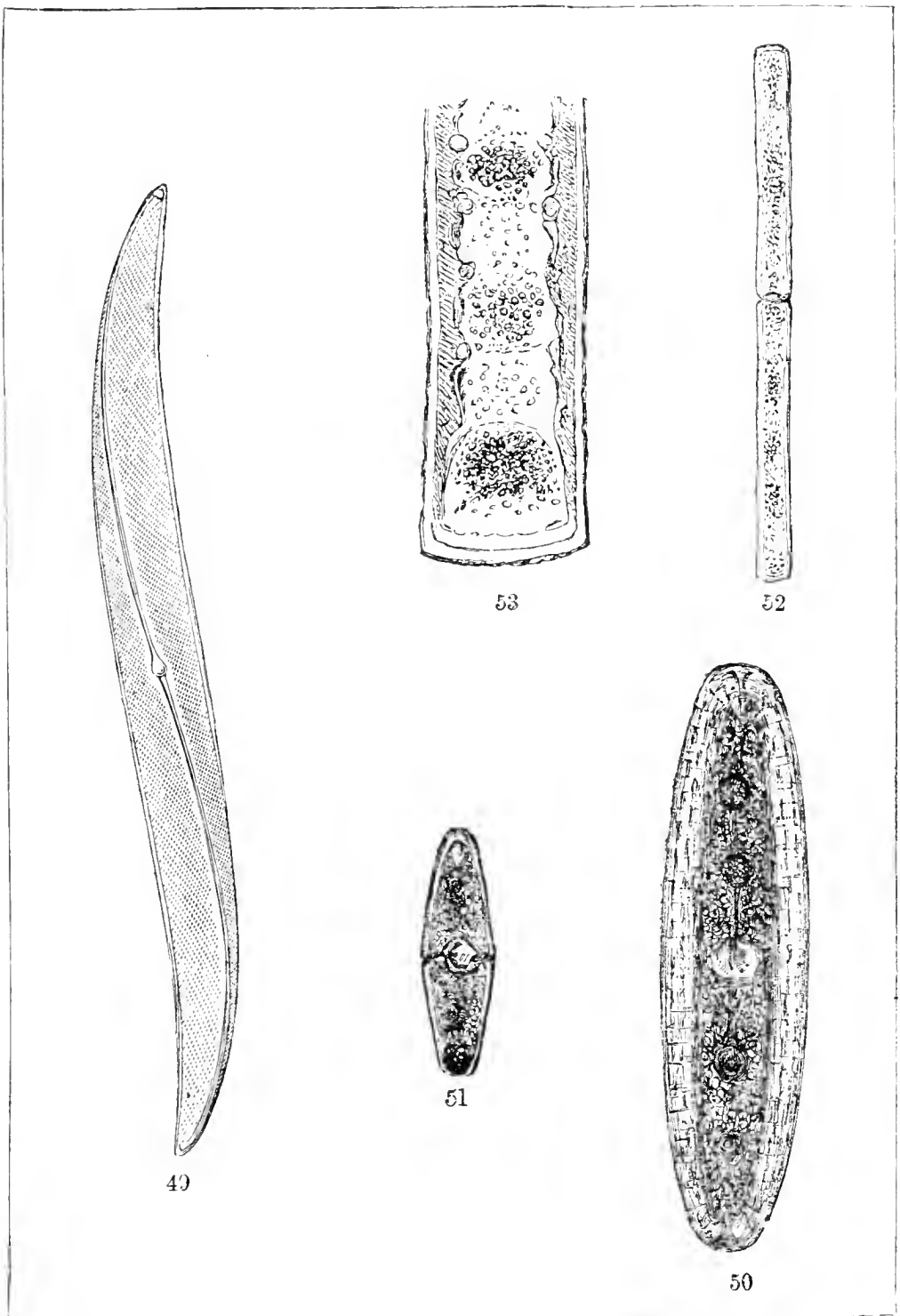
With regard to the species of Chroolepus, it is as well to mention that its filaments lose their characteristic yellow

or red tint during the process of drying, and assume a grey appearance. An odour like that of violets is common to all the species, and is particularly observable when large quantities are brought together. However, colour and smell must not be taken as characters of any great value: the true distinguishing marks lie in the form of the cells, and the ramification of the rigid filaments.

The last of the three forms which I have grouped together in this chapter embraces the stone-like Algæ. This peculiar mode of growth may be seen in certain species which have the property of separating carbonate of lime from the surrounding water, and depositing it among their filaments. This peculiarity imparts a hard stiff appearance to the latter, so that to the uninitiated they appear to be made of stone. In shape these Algæ are usually semiglobose, and adhere tightly to stones, piles, breakwaters, and similar submerged objects. Where they can be taken off by hand, it is better to adopt that plan; but if fixed too closely for the fingers to be of any use, recourse must be had to the hammer and chisel. The specimens may be put away in a paper case; or, if thin enough, fastened on a sheet of stout paper with gum arabic.

Before the specimens can be examined under the microscope, the carbonate of lime must be dissolved, as of course its presence renders them opaque, even when very thin sections are made. This can, however, be easily effected by leaving the Algæ for a sufficient time in dilute muriatic acid. Indeed, common vinegar, though not so rapid in its action, is just as efficacious. Bubbles of carbonic acid begin to burst through the surface of the liquid, and so long as this ebullition continues it is certain that lime is still present. The gas having thoroughly escaped, the preparation will be found in a flaccid condition, and sufficiently soft to allow of very thin sections being cut from it by means of a sharp razor. These should be forthwith laid in a watch-glass and once more submitted to the acid,

in order to remove the last trace of lime. After waiting a short time, the sections may be removed with a soft brush into a saucer, and the acid washed out of them. This last circumstance should be carefully attended to, as the gases released from the acid are apt to attack the lenses and do them serious injury. The object is now ready for examination under the microscope, for which purpose it has simply to be laid on a slide under a thin covering glass. A gentle pressure given to the latter will cause the filaments to recede from one another, and ensure the transparency of the preparation.



49. Pleurosigma formosum.
50. Penium digitus.
51. Penium navicula.
52. Docidium clavatum.
53. Docidium clavatum, end of frond.

CHAPTER X.

OF THE MARINE ALGÆ.

The beauty of colouring and delicacy of form exhibited by the generality of the Algæ inhabiting the ocean have always made them great favourites with botanists; and even those persons for whom botany has no charms may be seen eagerly searching for these lovely plants among the *débris* scattered along the seashore.

Of course, where the student has the opportunity of gathering them for himself, it is far better to study their habits and watch their changes of growth in their native haunts, than to trust to dried specimens: moreover, he will be saved much time and patience, both of which are largely called for in the task of disentangling a complicated network of Algæ which have lain long between the sheets of an herbarium. Nevertheless, there are many who are either altogether debarred from visiting the seaside, or can do so at long intervals only; but even these need not despair of making acquaintance with the marine flora. Besides, it often happens that the collector is prevented by want of time from at once preparing a large number of specimens for the herbarium. It is well then to know that Algæ which have been roughly dried for mere preservation will, upon being carefully remoistened, regain so much of their natural beauty as to please even a critical eye. Indeed, under certain circumstances, this preliminary drying has positive advantages. For instance, there are certain species which have the unpleasant peculiarity, when the fresh specimens are being dried, of discharging a portion of their cell contents, thereby spotting and staining the paper on which they lie. Such are the genus Aglao-

phyllum, several of the Callithamnia, Polysiphoniæ, &c., all of which ought to be placed a second time under the press before really good preparations can be hoped for. Other species (as those of Wrangelia) are completely spoiled by being immersed in fresh water * while in a living state, as it turns them to the colour of ink.

These untoward events may be met by giving the plants a preliminary drying on some stout paper, just as they are taken from the sea. To prevent the paper from wrinkling, it is advisable to load the corners with weights; or, better still, to press the objects as soon as they are tolerably dry between sheets of blotting paper. The fact of a few pieces of the drying material clinging here and there to the Algæ is of no consequence, as they may be easily removed afterwards by applying a little water with a soft hair pencil.

The possibility of rearranging Algæ, at a future period, which have been already dried, is (as I observed just now) of the last importance to botanists who can rarely visit the coast, as it gives them an opportunity which they could not possibly have otherwise of becoming acquainted with these lovely denizens of the sea. For while mere preparations, however beautifully got up, can give but a very imperfect picture of the plant itself, these same examples, when once more acted on by water, represent very fairly its original habit, and afford the student abundant material for investigation.

With no group of Algæ is the caution more needed than with this, to be most careful in preserving the natural habit of the plant. To be led away by the mere love of the beautiful, or what the operator is pleased to consider the beautiful, is fatal to the prosecution of science. In the case

* I take this opportunity of observing that, sooner or later, all Marine Algæ *must* be immersed in fresh water before the final drying. If this precaution is neglected, the salt contained in their tissues will absorb such an amount of moisture from the atmosphere as will keep the plants in a continual state of dampness and mouldiness.—Ed.

before us it leads him to sacrifice the true relation of the different parts to the prettiness and neatness of the preparation, to force branches into unnatural positions because they appear to him to look better so, and generally to distort the whole plant. All this may possibly make a pretty object for the herbarium, but it alters its whole character and destroys its value in the eyes of the real botanist.

We will imagine the reader to have received a packet of dried Algæ from a friend at the seaside. The first thing to be done with each of the specimens is to immerse it in clean soft water, and let it remain there until it has become sufficiently flexible to allow of its being lifted without injury from the paper to which it was fixed. The movement may be aided by inserting a blunt knitting-needle between the paper and the plant, so as to raise it gradually from its bed. Let this be done very slowly and carefully, as too much haste is almost certain to tear the specimen and entangle the filaments. As soon as the plant floats freely in the water, it must be rubbed and kneaded between the fingers (roughly or lightly, for a longer or a shorter period, according to the degree of coarseness and general consistency of the specimen) until the different parts have ceased to adhere together. When this is effected, the needle is again brought into use (the plant still remaining in the water), and is slowly drawn, beginning at the root end, through first the upper, then the middle, and lastly the lower stratum of stems and branches. In this way knots and entanglements are got rid of; and it enables the operator to ascertain whether he is dealing with a single plant or a whole colony—a circumstance of some importance, as the crowding together of numerous plants makes it very difficult to recognise the true character of the species.

As soon as order is introduced among the tangled plants, the whole mass should be divided into portions, each of such a size as is likely to make a good preparation. And here let me caution the student to choose for preservation

only whole or perfect specimens; by which I mean such as are provided with the disk by which they were fixed when in life, or at any rate with as much of it as possible, in order to exhibit the plant's natural habit. Fragments torn off the main stem look very pretty, and do well enough to adorn a lady's album, but, as a rule, are valueless to the botanist. In many cases it is absolutely necessary to have the entire plant before one's eyes to determine with certainty its place in the system of nature. I will bring forward a single example. The genera Callithamnion and Phlebothamnion are separated on the ground of the former being 'corticate'—that is to say, furnished with a cortical or external integument, which is wanting in the latter. Now, there are instances (as I have myself repeatedly experienced) where this outer stratum is developed for a short space only above the point of attachment, the whole of the upper portion of the stem being naked. If, then, the student (instead of gathering the whole plant) is contented with specimens taken from above the portion invested with cortex, how is it possible for him to determine to which of the two genera his example belongs, since he has deprived himself of the only characteristic mark by which they are distinguished? Much the same may be said of the different species of Polysiphonia.

When, again, the collector comes across Algæ flourishing in large tangled groups, he must take care while separating them to secure a sufficiency of material for future observation. It is a sound axiom in domestic economy that frugality applied in the wrong place does but aggravate difficulties. And it is as true here as in the more serious matters of life. Many a chance of determining the true position and natural habit of a plant has been lost from the collector having neglected to gather sufficient material on the spot and at the right time. A single stem of a Ceramium may perhaps exhibit the generic and specific characters sufficiently well; but, however beautifully laid out, it can never set before the eye of the observer the great massy

tassels and soft flowing tresses which distinguish most of the Ceramiaceæ. So far, then, the study of æsthetics has a claim upon the botanist; only let him beware of allowing it too far, by giving that a first claim on his attention which should in fact be a mere means to an end. Besides, a needy hungry-looking set of specimens always detracts from the good appearance of an herbarium: it repels rather than invites the attention; whereas a rich series of well-prepared examples awakens in the observer's mind an agreeable feeling of the beauty and perfection of the works of nature: it may be, even deeper and more lasting sensations—wonder, praise, and thankfulness to the great Creator.

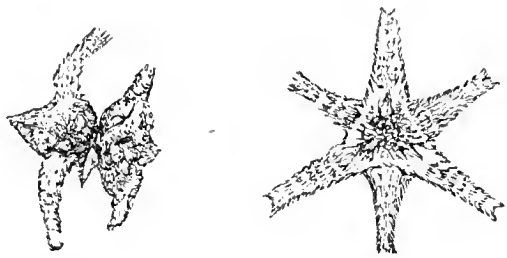
Having * now divided the group of plants into fitting portions, each tuft is to be laid separately on the edge of a plate, not in the water, but just on the side, so that it may imbibe a sufficiency of moisture during the ensuing operations without being actually immersed. Next, let a piece of stout white writing or drawing paper, of a size corresponding to the object under preparation, be pushed under the water slowly and carefully, so as to prevent air-bubbles from pressing on the lower surface, as they are very apt in the subsequent treatment to cause an unequal expansion in the paper, thereby raising folds and wrinkles. The paper being ready to receive the Alga, the latter may be drawn gently over it, with the root end towards the operator, the stem and branches being kept from entanglement by means of a smooth blunt needle (a broken ragged end to the needle will do more harm than good, by tearing the delicate filaments), due regard being had to their natural position and the angle at which they ramified from each other during life. As soon as the larger branches are laid in the right direction, attention can be given to the minor branches, or pinnules, the position of which is in a great measure regulated by the way in which the paper is drawn out of

* From this point the suggestions offered refer alike to freshly-gathered Algæ and to those which have been long dried.

the water across the edge of the plate. If this be done deliberately and without undue precipitation, the tiniest even of the branchlets and filaments will fall one after the other into their proper place.

Excellent as this plan is in its results, there is no doubt that it calls for a large amount of patience and foresight, and takes a good deal of time to carry out properly. Indeed, so much of its ultimate success depends upon the perfect quietude of the materials under operation, that not unfrequently an unlucky jerk of the arm or an ill-timed blow on the table will send the water streaming in the wrong direction, and mar the whole proceeding. I will therefore give another method, which, although its results are not more pleasing to the eye, is certainly much more easily carried out, and therefore less trying to the young student's peace of mind.

According to this plan, the paper, with the specimen on it, is drawn out of the plate and laid on a small tin dish, the bottom of which has been previously overlaid with a piece of paper of about the size of the object to be operated on. Two of these tin dishes should be provided, of different sizes—the cost is a mere trifle—one measuring about fourteen inches by nine inches, and the other and smaller nine inches by five inches—each having the edges turned up say half an inch, so as to retain the water. The only other requisite is a small glass syringe, such as is used for medicinal purposes, and which may be purchased for a few pence at almost any glass or chemist's shop. With this last instrument pour a gentle stream of water over the Alga as it lies in the dish, and continue to do so until the smaller filaments and pinnules begin to float—the stem and main branches, from their superior weight, still resting on the paper. It is an easy task now to insert a needle among the floating ramifications, and not merely reduce them to order, but bring them as nearly as possible into the same position they were wont to have when in their natural localities. The most delicate branchlets of



a *b*

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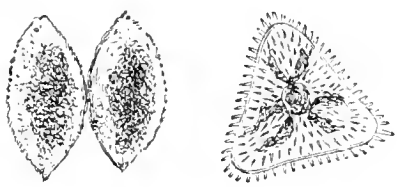

a *b*

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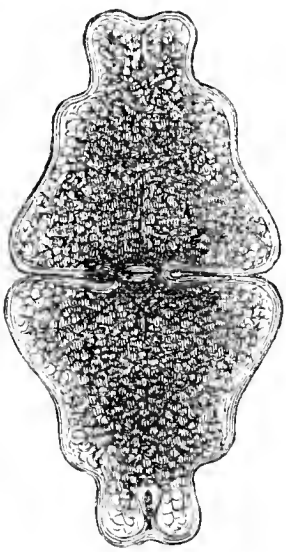

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a *b*

55

54. Staurastrum dejectum (*a*, end ; *b*, side view).
55. ,, gracile ? ,, ,,
56. ,, spongiosum (*a*, side ; *b*, end view).
57. ,, alternans ,, ,,
58. Euastrum didelta.

the Bryopsis species, of the Polysiphoniæ and Callithamnia, nay, even the curious apices so characteristic of the genus Ceramium, all yield to this mode of treatment, especially if it be aided by a hair pencil loaded with water and drawn slowly among the finer portions of the plant, should any of them still continue to cling together. This operation having been satisfactorily performed, the next thing is to withdraw the water. Here the syringe again comes into play, but this time as a suction pump. It is only necessary to place its open end between the larger branches, and by very slow movements of the piston the whole of the fluid will be drawn up through the barrel, and can be discharged into the plate. The eye will determine when the water has been sufficiently abstracted, but the ear is a still better guide. As soon as a bubbling sound is heard in the body of the instrument, it is a certain indication that air is taking the place of the water, and that the latter is exhausted. To empty the dish entirely it must be gently tilted on the side which holds the root end of the plant, so that the water shall flow towards the opposite side, where it may be drawn off with the syringe. The water having been thus got rid of, the operator will probably find it necessary to give a final touch with a hair pencil to some of the branchlets or filaments that have been displaced, especially if examples of the more delicate kinds be under treatment; the whole may then be lifted out of the dish and laid upon blotting paper, to undergo a sort of preliminary drying.

Although this process takes some time in describing, it is in point of fact of the simplest kind, and allows of each preparation being got ready in a very short space of time, because the operator works upon a firm, even basis; both his hands are free, and there is no large quantity of water to be displaced by a chance blow or shake, all which advantages are wanting in the ordinary method of preparing specimens in a plate or basin.

The preparation must not be left too long exposed to the action of the atmosphere, or it will be spoiled. The

very fact of the Alga and the paper on which it lies differing widely in their powers of absorption and evaporation is alone sufficient to cause the former to separate from its support during the process of drying. To meet this difficulty it must be submitted to a press, and left there until all the moisture is withdrawn. As was mentioned under the head of the Filamentous Algæ, there is nothing so good for the purpose as smooth white absorptive blotting paper. Let the preparation, already partially dried, be laid on half-a-dozen sheets, and let a piece of stearine paper be placed over it, adapted as nearly as can be to the size of the object. Next to the stearine comes another layer of blotting paper, then a specimen, and so on, until a pile is formed of a manageable size, according to the discretion of the operator. The whole is then to be placed between smooth boards and weighted with three or four bricks, as previously described at p. 68. Nothing more is to be done for some six or seven hours, when the damp blotting paper should be removed and a fresh supply inserted between the boards. The oftener, in fact, a change is made in the absorptive material, the better; as it tends to preserve both the colouring of the specimen and the clean white appearance of the paper on which it lies.

When changing the drying paper, the best plan is to turn the whole pile upside down, so as to get at the lowest examples first—the stearine paper, of course, now lying *below* the plants. Carefully remove the first layer of damp sheets, taking care not to lift with them the piece of white paper attached to the specimen. Lay the latter on a fresh stratum of blotting paper, and so proceed with each specimen, loading the whole, as before, with bricks. After the lapse of some hours the process must be repeated; in a word, the operator will find that his preparations are not merely neater, but also more true to nature, the oftener he gives himself the slight trouble required in replacing the drying material. In proportion as the moisture is got rid of, the latter must be reduced in quantity, until a single

sheet only is left between each specimen. In this state the pile should be left for several days, until the plants lie quite flat and all danger of their curling up is past.

It frequently happens that the gelatinous Algæ, such as Mesogloia, are found adhering by their upper surface to the stearine paper; but there is not the least necessity to try and separate them, as a beginner might be tempted to do: any such attempt would only end in the destruction of the specimen, or at any rate in the spoiling of its appearance. He has but to 'leave well alone,' to let the Alga remain as it is until it is perfectly dry, and the stearine paper will then spring off spontaneously, or in any case may be easily separated without the least injury being done to the preparation. Even if small fragments of the paper should adhere to the Alga when it is taken off, it is easy enough to remove them by simply touching them with a moistened hair pencil, waiting a short time until the fragments are saturated, and then scraping them gently with the sharp edge of a penknife. The portions that have been wetted quickly dry up, and the preparation has as neat an appearance as before.

A few species, especially those belonging to the genera Schizonema and Ectocarpus, must not be placed under a press at all. The fronds are too tender and too soft to bear the weight of the superincumbent bricks. At the same time, the reader will have gathered from the previous remarks that drying in the open air has a tendency to crumple the paper on which the Alga lies. But this difficulty is to be got over by a little perseverance. As soon as the plants are thoroughly dried, let the paper be dipped into a basin of clean water, remaining there for a few seconds—in fact, only until it is wetted through and bends with facility. Take it out quickly, and having placed it between some sheets of blotting paper (with the usual stearine cover on the object), draw the hand backwards and forwards over the pile until the previously wetted paper has discharged all its moisture. In this way it will recover its smooth appearance

without the object itself giving out sufficient mucous matter to allow of its adhering to the stearine cover.

Up to this point we have had before our eyes only those forms of Algæ which divaricate into almost infinite ramifications. I have treated so largely of them, partly because of their overwhelming number, partly on account of the difficulty involved in preparing them for the herbarium.

There are, however, numerous other forms, consisting mainly of broad flat membranes, thicker or thinner according to the individual species. These are to be simply spread out on white paper and laid under the press, any folds and wrinkles having been first smoothed down by means of a soft hair pencil. There are certain exceedingly delicate species (among them may be named the Delesseriæ, several species of Callithamnion, and some of the finer Polysiphoniæ) which do not require any pressure at all. Laid upon white paper they dry up in a very short time, adhering closely to the surface, and looking, in fact, more like a painting or work of art than an object of nature. Others, of considerable thickness, should be treated after the fashion recommended in chap. vii. for some of the fresh-water species. They will adhere readily to the paper, and give no trouble in that respect. At the same time, the student must notice whether the under-surface of the frond exhibits any sort of characteristic clothing. This is the case, for instance, with individuals belonging to the genus Peyssonelia, in which the lower part of the frond is thickly coated with jointed hairs. Where anything of this kind is seen to exist, the specimen had better be deposited in a paper bag of suitable size, instead of being fixed down, so that on being taken out either side of the frond may be examined.

The large Laminariæ call for the same kind of treatment in its general principles, though varying somewhat to meet the exigencies of the case. These giants of marine vegetation are far too large—they often extend to a distance of eleven or twelve feet—to allow of their being dried and

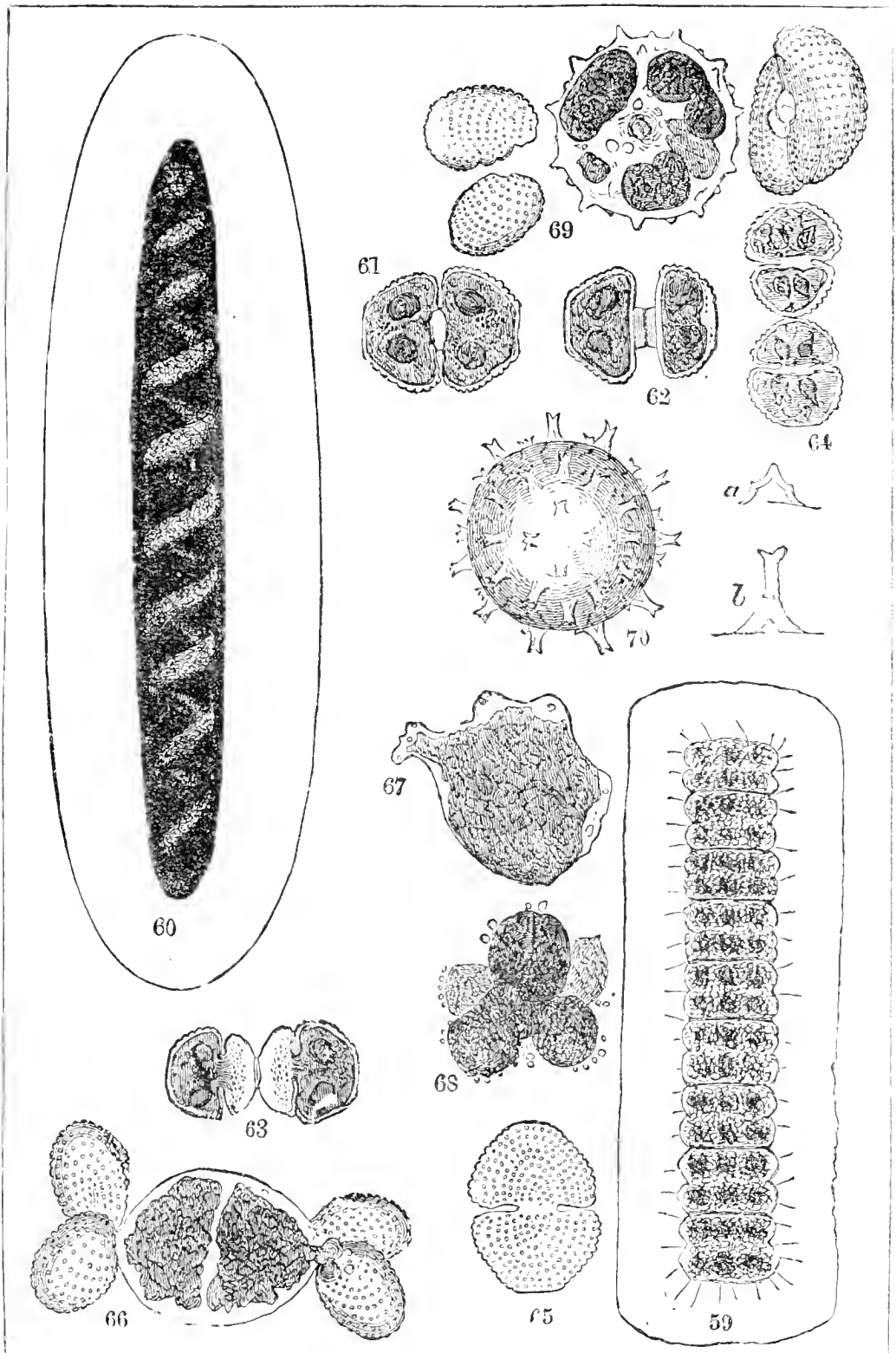
pressed in the ordinary manner; while at the same time the specimens lose a great deal of their interest and attractiveness if their fair proportions are too closely shorn. It is necessary, then, to select a middling-sized example for preservation; but even a middling-sized example will need a press far beyond the usual limits. Fortunately, the student has no need to dread a failure, so far as his materials are concerned. He has only to cover the floor of a room pretty thickly with sheets of blotting paper—the covered space measuring about six feet by three—and then to lay over this the Laminaria, which must be so far dried beforehand as to have lost the slimy feeling which it usually communicates in the growing state. More sheets of blotting paper being spread over the Algæ, the whole is to be covered with a smooth board of corresponding size (or in default of one so large, with several smaller boards), upon which a sufficient quantity of bricks should rest. If, after all the pains taken, the specimen is found to be too long for any reasonably sized press, the lower end of the frond may be turned over, not immediately upon the body of the plant, but at an oblique angle—blotting paper being laid inside the joint, so as to keep the parts from actually touching each other, where it is impossible to prevent them from coming together. The papers should be frequently changed, as the thick leathery substance of the frond makes the process of drying somewhat dilatory. However, the business of changing the layers of paper is rendered less tedious, in spite of the bulky nature of the object, on account of the firm though flexible character of the frond, which allows of its being moved about at will without any fear of damage Of course, a plant containing so large an amount of fluids in its cells requires not only a frequent change of the blotting paper, but also a more than usual amount of time—a fortnight or three weeks will not be found too long—to ensure its being thoroughly dried, and to get rid of all its folds and wrinkles. These last, however, I regret to say, are very apt to return at a later period, as it is impossible

to lay such monstrous specimens between sheets of writing paper, or to put them away in the herbarium cabinet. The consequence is, that they are more or less exposed to the action of the air, which is almost sure after a while to impart to them a considerable amount of moisture.

In examining this class of Algæ it is necessary (if his investigations are to be of any value) that the student should make himself acquainted with their anatomical structure. In numerous cases this is by no means difficult, on account of their transparent nature, which allows of their whole inner structure and delicate cellular tissue being examined at leisure under the microscope. In those species, however, which are furnished with a thick leathery frond and stem, it is requisite to cut fine sections, otherwise their opacity effectually prevents any view of the form and arrangement of the cells. [With regard to this part of the subject I must refer the reader to works in which the methods of preparing objects for the microscope are described at length: as, for instance, 'Davies' Preparation and Mounting of Microscopic Objects,' where the whole matter is thoroughly discussed.—Ed.] I will only observe here, that the examples to be operated on had better be quite dry, because in their wet state they are very apt to get torn instead of being accurately cut, the cells coming apart and hanging together in disorder. The section must be placed in water or spirits of wine, and left for a while to absorb the fluid; it is then fit for examination on a slide.

The lime-producing Algæ (by which I mean Corallina, Jania, Acetabularia, Liagora, Melobesia, and similar genera) must not be submitted to the knife until the incrustation has been entirely dissolved by means of an acid.

It is often very difficult to detect the true structure of the cell walls in the strictly gelatinous Algæ, as also in many of the Enteromorpha and some other families. The best plan in such cases is to add a drop of a solution of chloride of zinc and iodine to the fluid in which the section is immersed on the slide. By this expedient a conspicuous blue



59. Hyalotheca dissiliens. 60. Spirotænia condensata.
61 to 70. Cosmarium botrytis.

tint is communicated to the cells, giving them a clear sharp outline.

Contrary to the plan previously adopted in this little work, we have not yet touched upon the subject of the collection of the marine Algæ. The fact is, the individuals belonging to this huge family are so exceedingly numerous, and occur in such an infinite variety of localities, that it is impossible to do more than offer some general suggestions.

The best rule to observe is, to search every habitat diligently, and to take careful note of all that meets the eye; not, in a word, to pass by the smaller and humbler species in favour of their gaudier and more prominent relatives. This is by no means a rare fault with the botanical tyro. He allows his imagination to be impressed by some magnificent representative of the larger Algæ, forgetting that the lowly object, which he crushes under foot without remorse, should have at least as much interest in his eyes. And the consequence often is, that he has to lament the loss of a specimen which would have greatly aided him in his studies, and afforded him much genuine pleasure—a loss which is sometimes irremediable.

Marine vegetation depends largely on the character of the coast line. Sandy shores are the least promising; mud flats are not satisfactory hunting grounds: it is on a bold precipitous coast that the collector may look for the largest returns. This is especially the case where the receding tide is caught in rocky hollows and basins, for here the loveliest of the seaweeds are sure to be found, spreading abroad their delicate filaments, while the coarse, leathery kinds cluster about the rough blocks that overhang the crystal pools.

Even in spots where old Ocean shows himself in his roughest mood, and breakers roar and burst against the iron-bound cliffs, even there these tender plants are to be seen tossed about by the wild waves, or clinging closely to the rock, as if in defiance of their utmost efforts to dislodge them.

They are to be found too at all depths. A few, principally Fuci, seem to revel in the scorching rays of the sun, appearing to be quite satisfied with an occasional sprinkling of salt water. Some flourish best about high-water-mark; others where the tide reaches its lowest point; while large numbers, and those too of the brightest colours, delight to grow in depths to which, it must be supposed, the rays of the sun never penetrate. These latter, of course, are not very easily to be got at; and the collector must, as a rule, trust to the action of storms and hurricanes to supply the coveted specimens. Nevertheless, if he is blessed with the 'æs triplex' so requisite for all 'who go down to the sea in ships,' he will do well, when the opportunity occurs, to accompany a fishing crew on one of their trawling expeditions. He will be rewarded by finding among the refuse of their nets many an interesting plant, which would otherwise remain beyond his reach.

The character of the marine vegetation also depends greatly on geographical considerations; indeed, far more so than does the freshwater Flora. With regard to the European coasts, those washed by the Mediterranean, the Adriatic, and other southern seas, abound particularly in the genera included under the great 'Red' group, known as the Florideæ; while the 'Olive' genera, the Melanosporeæ of systematists, preponderate on the northern shores. As we approach the equator we find the Algæ assuming a size and brilliancy of colouring far surpassing anything we are accustomed to see in the temperate zone.

[The figures on Plates XVI. and XVII. will assist the young Algologist in recognising members of the great 'dark-spored' group, the commonest on our shores, and generally the first to strike the eye of the beginner.—ED.]

CHAPTER XI.

OF THE CHARACEÆ.

THE INDIVIDUALS grouped under the term Characeæ have found a great difficulty in establishing a place in nature. They have been a kind of vegetable outcasts, 'casuals,' without any special ward assigned to them! The truth is, that while their organs of reproduction are those of a Cryptogam, their external form so nearly resembles that of many of the higher orders, that the earlier botanists may well be excused for having given them a habitation among the latter. The great Linnæus ranged them in his class and order, Monœcia Monandria, removing them, strange to say, from a place which he had formerly given them, and which was much nearer to the truth, among the Cryptogamia, not far from the Lichens. Jussieu, De Candolle, and Robert Brown retained them among the Phanerogamia; Agardh and Wallroth referred them to the Algæ. Only recent authors, Hooker, Lindley, &c., have allowed their claim to a separate order, and have fixed their identity as members of the Cryptogamic family. But even now the unfortunate Characeæ are far from finding permanent rest, being bandied about from one neighbourhood to another, from Algæ to Fungi, and from Fungi to Lichens and Equisetaceæ. Without pretending to lay any claim to systematic accuracy in this little work, I believe that we are adopting a right course in placing our troublesome *protégés* between the Algæ and Fungi; their tubular stems recalling the former, while the spore-like bodies contained in the nucule seem to mark their affinity with the latter. Like many of the Algæ, too, a large number of Charas are gifted with the power of encrusting their stems and branches

with carbonate of lime; an unfortunate property for the collector, as it renders them so brittle, that he has some difficulty in securing plants in a perfect condition.

All the Characeæ prefer, for their habitats, ponds and ditches with a muddy bottom, and in which the water is clear, although stagnant: they are rarely found in swiftly flowing streams and rivers. As a rule, they prefer shallow pieces of water, though many species flourish at considerable depths in the larger lakes. Some, perhaps a fourth of the European varieties, delight in brackish water; a few in the sea itself. Their geographical range is wide, being found in greater or less abundance in every quarter of the globe, although most common in the more temperate climes.

On account of the extreme brittleness which characterises these plants, it is extremely difficult to handle them without breaking off portions. A first consideration, then, with the collector is to avoid entangling the individuals as they are brought out of the water, as his subsequent efforts to separate them from each other will cause him infinite trouble and vexation.

There is no difficulty in collecting them, when they chance to grow near the bank. The collector must dip his hand into the water, and seizing a tuft of the plants as near to the root as possible, grasp them firmly and draw them up to the surface in such a way that they shall not bend over on themselves, and get their branches twisted and jumbled together. Before attempting to get rid of the mud, quantities of which are sure to be clinging about the root, the upper clean part should be enveloped in paper: this will prevent it from getting dirtied, and will keep the stem and branches from entangling. Then hold the roots in the water, kneading them softly with the hand, but not drawing the fingers through them. The purified masses may then be laid lengthways between folds of damp paper and carried home: a portfolio is the best and safest mode of transport. The greatest care must be taken not to allow

the specimens to dry up before they are properly laid out, as their brittleness is increased a thousandfold when they have lost their fluids. Hence the necessity of sprinkling them with water on reaching home, if they are to be left for any time before being got ready for the herbarium; but the best plan is to set about preparing them at once.

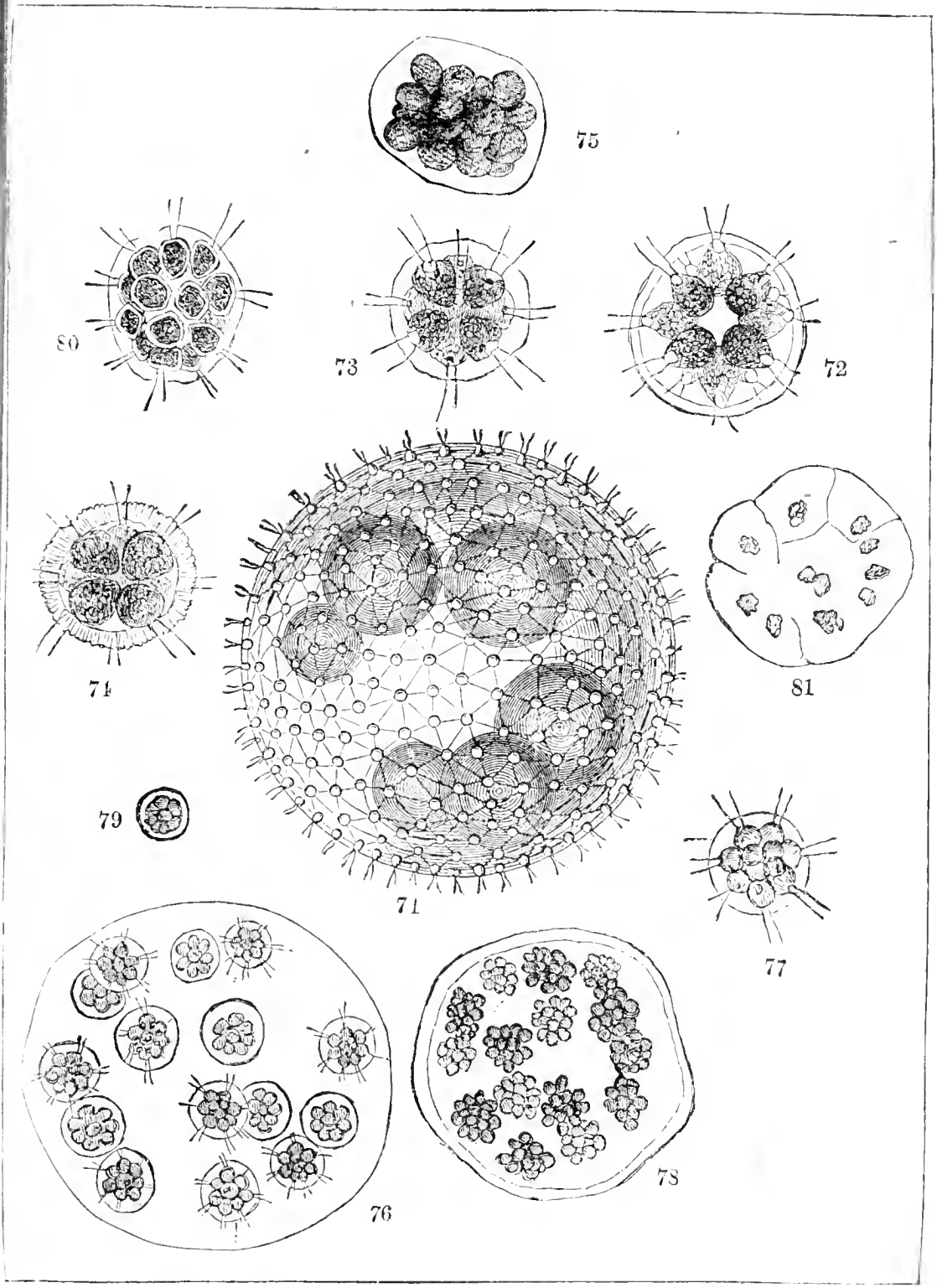
Where the species grow in very deep water or beyond the reach of the arm, it is requisite to employ the double rake, which has been already described at p. 5. If the collector has a boat at his command, it is better, as of course he has so much larger an expanse of water on which to make his experiments; otherwise he must confine his efforts to the comparatively small area, embraced by the distance to which his line will reach from the bank. In any case the rake must be allowed to reach the bottom, and then dragged slowly along (if in a boat, the movement of the latter as it floats without the use of oar or paddle, will give sufficient impulse to the rake) until a check is felt, upon which it must be drawn up and the booty secured. It is rare that this little instrument, if made according to the instructions previously given, fails in the services required of it. Of course in fishing in such deep waters, it is impossible to guess what they will yield, and a good deal of worthless stuff will be dragged into the boat. However bright and clear the waters may be, it requires an experienced eye to detect what may be growing at the bottom; and even that resource is cut off if the slightest wind ruffles the surface. But, generally speaking, the collector will be able to judge pretty well of what he may expect to find by paying attention to the fragments cast on the banks. In places where irrigation is carried on, it is advisable, in the winter and spring when the fields are flooded, to examine the masses of duckweed, sedges, &c. that are scattered about. The chances are, that he will hit upon some minute fragments of Chara, indicating what he may expect to find worth gathering later in the year. Among the Characeæ themselves too he will frequently

come across small portions of other species, proving that the latter grow somewhere in the neighbourhood and may be got at by diligent search. Not unfrequently several species grow together in a single colony; or again numerous kinds may flourish in distant parts of the same piece of water, requiring close observation on the part of the intelligent botanist, who will not be content with securing a solitary specimen, but will take a careful survey of the banks step by step. He will bear in mind, too, that in this order several species bear a close resemblance to each other, while they are wet; whereas, on being dried, which speedily takes place on being exposed to the air, the specific differences are easily seen, as they depend mainly on the manner in which the tubular stem is formed.

The first step to be taken in preparing the Characeæ for the herbarium is to lay the larger masses on a table, divide them into smaller portions, and then extract the individual plants. I recommend this being done on a table and not in water, because the plants we are dealing with have a strong tendency to intertwine their branches, especially if there is any movement; and this is almost unavoidable in the fluid on which they rest.

The separate specimens may now be dropped into a basin of water, those only having been selected which are furnished with root, stem, and branches; for, as in the case of the Phanerogamia, those examples only should be preserved which give a true picture of the whole plant. No mere fragment, however pretty to look at, is, under ordinary circumstances, worth the attention of the botanist.

Now let a piece of stout paper of the proper size be inserted under the Chara, and let the latter be drawn over it root foremost. The only further care necessary is to draw the paper slowly out of the water, and with a blunt needle re-arrange any branches which may have been displaced. Leave the paper undisturbed for a short time to let the water drain off, then lay it on some sheets of blotting paper, and cover it with stearine paper. This may be



71. Volvox globator. 72 to 81. Pandorina morum.

repeated until a convenient pile is formed, which should be forthwith submitted to the press. After the lapse of a few hours the damp blotting paper must be removed, and replaced by dry material, special care being taken not to disturb the stearine covering, as the Characeæ are very apt to cling to it: but this is of no consequence, as they will easily separate as soon as the specimen is perfectly dry. If, on finally removing them from the press, the plants do not adhere completely to the paper on which they lie, a little gum-arabic may be placed under the stem and principal branches.

The extreme fragility of the Characeæ must never be lost sight of during their preparation, and the drier they become, the more strongly marked is this tendency to break up into fragments. This tendency remains even after they are placed in the herbarium: the only remedy I can suggest is to insert a very thin layer of common wadding between every half-dozen sheets of the prepared specimens. The wadding, however, must be previously moistened with benzine or corrosive sublimate, or sprinkled with camphor; otherwise it is but inviting the attacks of Anobia and Dermestes, and similar destructive insects.

The Characeæ being of a comparatively large size, a low power only of the microscope is needed for determining their characteristics; indeed an ordinary lens is generally sufficient. The stratum of carbonate of lime, which invests the majority of these plants, must of course be got rid of by means of an acid, before any observations can be made on their inner structure.

The species of Nitella, as being entirely free from this incrustation of lime, afford the best opportunity to the student of watching the wonderful phenomenon known, in technical language, as 'cyclosis,' or 'rotation of the protoplasm,' but commonly called 'circulation of the sap:' *this*, however, it is not. Under a power of not less than 200, green globules are seen to circle round and round each of the cells. But these globules are not the sap,

but granules of chlorophyll (the substance which gives the green colour to plants), and they are being forced along by a current of mucilaginous matter, termed protoplasm. What the purpose of this never-ceasing rotation may be has not yet been discovered.

In the Characeæ, also, may be observed the movements of the spiral filaments or spermatozoids, which swim actively in water, on being pressed out of the globule or antheridium.

CHAPTER XII.

OF THE FUNGI.

As the Algæ require water in larger or smaller quantities for their support, so the Fungi demand for their perfect development the decaying remains of other organisms. Wherever rottenness and corruption are present, there are we sure to meet with a rich Fungal vegetation. Let a plant for instance be sickly, it is seized upon immediately by a host of parasites belonging to this class; their cotton-like mycelium penetrating its cellular tissue, disorganising its structure, and extracting nourishment from its infected juices. Wet wood, fallen leaves, animal excretions, all afford a nidus for these scavengers of nature, who only spring from the earth itself when the latter is rich in humus, or, in other words, in decayed vegetable matter. For a like reason they are to be found in abundance on damp tree stems and in mines and cellars, where fragments of rotten wood supply the conditions necessary to their existence. It must not however be imagined, that, because they are found in deep mines or in cellars, into which the rays of the sun never find their way, Fungi are less dependent for their perfect development on the action of light and air, than the more highly organised members of the vegetable kingdom. The fact is, that they exist in these localities only in a certain condition, as byssoid products or mycelium; they never come to *perfection*. It is a matter of grave doubt to this day, what is the perfect form of the well-known Rhacodium cellare.

There is in truth scarcely a single object in the whole realm of nature which is not liable to the attacks of these minute enemies. The timber of our houses, as many a

landlord knows to his cost, crumbles into dust under the influence of 'dry rot' (Merulius lacrymans). Our bread, our cheese, our ink, and an infinite number of similar household matters—only let the conditions be favourable—are quickly overrun with the delicate Fungi, which, in common language, are grouped under the name of 'mould' (Mucoraceæ and Botrytaceæ). A stroll in the garden, or a walk through a field, shows us how readily our flowers and cereals succumb to the insidious growth of 'smut' and 'brand' (Uredinaceæ). Nor are the members of the animal kingdom one whit more exempt from the assaults of the common enemy; while Empusina fixes itself on the common house-fly, and Torrubia on a caterpillar,* Muscardine is the name of a so-called disease which destroys myriads of silkworms in sunny Italy, and which is in fact nothing but the mycelium of a Fungus (Botrytis bassiana), growing within their bodies and consuming their vital powers.

The most favourable situations, however, for the development of the Fungi are undoubtedly those where a moderate degree of dampness is united with an equable and not too high temperature. Hence forests and woods are certain to provide the collector with abundant material, since they are rich in the elements most needed for the production of Fungal life; viz. organic substances in a state of decay, shelter from cold biting winds, shade, and moisture. For like reasons, old thick hedges, not too much exposed to the sun, often abound in crimson Peziæ, orange Tremellæ, and the curious nest-like Nidulariæ. Warm rains also in the autumn are favourable to the growth of this class, so that it is not an unusual thing to see astonishing quantities of mushrooms in the fruiterers' shops, or to come across gigantic puff-balls and boleti in the woods, at that time of year, when they have been quite scarce during the hot summer months. Not that the germs depend for their growth on any particular

* On Plates XVIII. XIX. (96, 97) are given several examples of this singular parasite.

season ; at no period, other circumstances being favourable, need the collector fear to return home from his excursions empty-handed.

His outfit is comprised in a few words:

1. A bag, or rather knapsack, the back and front of which are kept apart by two or three pieces of stout mill-board—these same pieces dividing the interior into separate divisions. The use of this knapsack is for the large thick specimens—the Agarics (Plate XXIV.), Helvellids (Plate XIX. 98), and Lycoperdaceæ (Plates XIX. 99, XX.), also pieces of wood on which minute Fungi have fixed themselves.

2. An old book, in which to carry leaves and other thin parts of plants; the habitats of Pucciniæ, Lecytheæ, &c. An india-rubber ring will keep the whole together.

3. A supply of chip and pill boxes, and small wide-mouthed bottles. These are all useful for the transport of the more delicate Fungi.

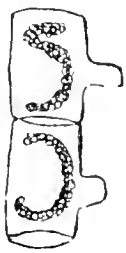
4. Paper for wrapping up the objects.

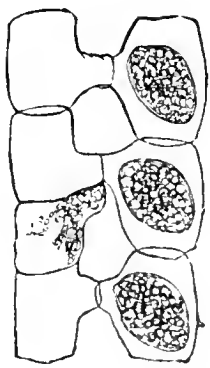
5. A strong sharp knife.

Armed with these, and taking care to keep a good look-out among trees and bushes, hedges and palings, the collector may fairly expect to reap the reward of his zeal in a well-filled knapsack. So strangely, indeed, do the Fungi vary in form and size, that his eyes must be at the same time both telescope and microscope. They must not only be able to embrace, from a distance, the outline of the great Bovista, but they must peer among dead leaves and decayed fragments of wood, and be able to detect the faint traces which betray the presence of an Aregma or a Triphragmium (Plate XXI. 102, 103). Every tree stem must be diligently searched, and careful glances thrown on the herbaceous plants around him : every broken limb and rotting bough lying in his path should be lifted up and examined above and below ; for it is on these, that Sphæria (Plate XXI. 104), and Asterosporium (Plate XXII. 105), and a host of other curious forms delight to grow.

True, the very minute Fungi are not to be detected by the naked eye, or at least very rarely; and it may seem superfluous to bid the young botanist search for what he cannot perceive. But in truth, though he cannot perhaps see them, he can see where they are; he can see spots and lines and fissures and excrescences; he can see distortions and discolourations, all of which announce plainly that the little miner has established himself, and is hard at work carrying out the mission entrusted to him by Providence. Of course judgment and discrimination are necessary here, as in every other department of science. Not every black spot on a cereal is an Ustilago, nor is every knob or distortion an Hysterium, or a Polycystis. Experience is, no doubt, of the greatest possible use; and, more than that, it *must* be bought; there is assuredly no 'royal road' to a knowledge of the Fungi. Nevertheless the student will do well, if it lies in his power, to seek the advice and counsel of an older mycologist; so that, on his first few botanical trips, he may have some kind of notion regarding the characteristics of the minute Fungi. If he is not so fortunate as to have a friend, who can lend him a helping hand, he must needs work the matter out for himself, and trust to his own tact and common sense to discover these tiny organisms where the eye of the uninitiated would see only a dirty spot, and at the same time to separate the worthless from the valuable.* By taking trouble at first to inspect the leaves in a living condition, he will soon get to notice those in which the Chlorophyll is beginning to fail, and which have in consequence a sickly appearance; an almost sure sign that the germs of

* I take this opportunity of commending to the notice of the mycological student, Mr. M. C. Cooke's admirable manuals, 'A Plain and Easy Account of British Fungi,' and 'An Introduction to the Study of Microscopic Fungi.' (Hardwicke.) The research displayed is only equalled by the clearness with which the results of the author's investigations are placed before the reader. To the beginner, especially, they will prove invaluable aids.—Ed.





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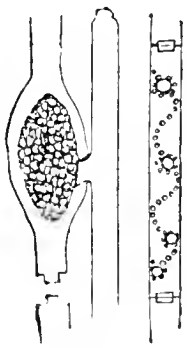

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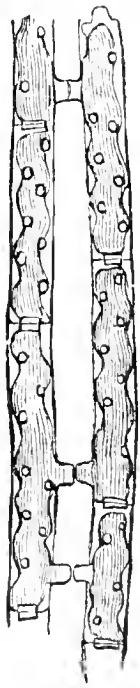

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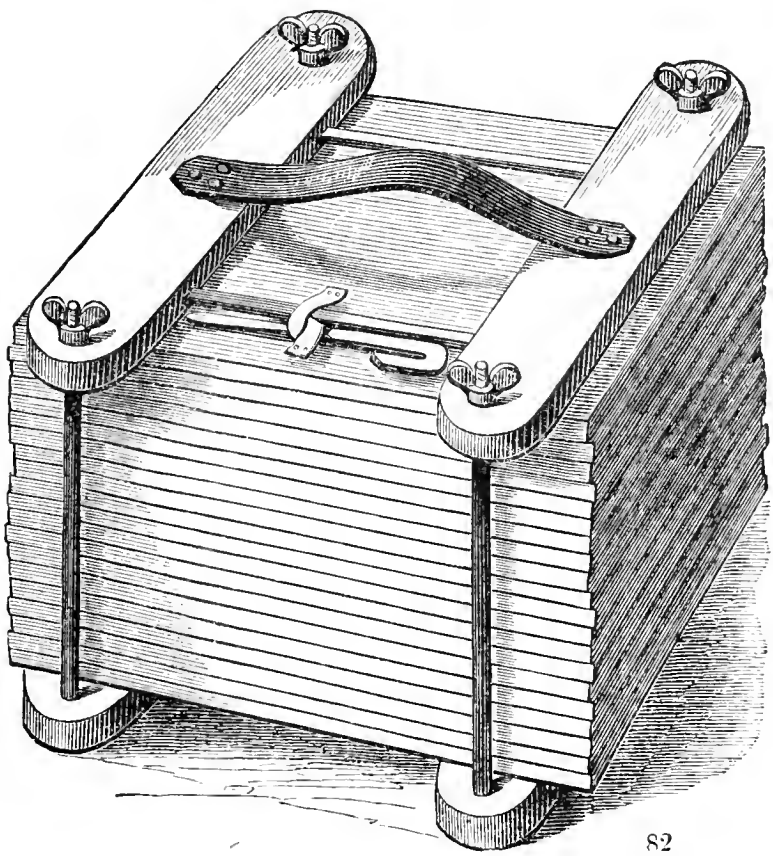


82

82. Press for drying Botanical Specimens. 83–85. Zygnemaceæ conjugating.

some destructive Fungus are developing themselves. All such leaves he will gather and place in his book for future examination; although, perhaps, there is nothing beyond this visible to the eye, to show what mischief is at work. By way of illustration, I will refer to the disease which so frequently seizes on the leaf of the potato during the summer. Its first attacks escape the vigilance of even the most experienced eye. Soon, however, a chemical change begins to take place in the Chlorophyll: the hitherto green leaf assumes a yellowish-brown tint, and is finally enveloped in a layer of white cobweb-like threads; all of which is due to the presence of a mould, known to botanists as the 'Peronospora devastatrix' of De Bary. Another minute Fungus may be observed in the form of a pale spot, which gradually envelops the leaf on which it is seated with a delicate web; and a very close inspection will detect tiny black dots scattered among the meshes. These are the conceptacles, or capsules, enclosing the spores; and the whole mass is the well-known 'mildew,' belonging to a genus Erysiphe, the members of which work sad destruction among roses, hops, peas, and numerous other plants.

Wherever, in a word, the eye of the collector detects an unnatural colour in a leaf, or a diseased appearance in a stem, it is worth his while to examine the sickly part, as the chances are greatly in favour of the evil being due to the baneful action of some Fungus. Thus the pedicel of the thistle, the leaf of the hawthorn, the ripening stem of the wheat plant, &c., are frequently swollen and discoloured by Æcidia and Pucciniæ (Plate XXII. 106), which have worked their way into the cellular tissue, and are rapidly destroying it.

But it is not the stems and leaves alone that are subject to the attacks of these active assailants. It is rare to stroll through a field of standing corn late in the summer, without finding traces of that terrible pest, the 'smut,' (Ustilago segetum), a dust-like agglomeration of minute

black spores, which in certain seasons propagate themselves in countless myriads, always taking up their abode in the ears. No less injurious is another microscopic Fungus, generally known as 'bunt' (Tilletia caries), which grows within the grain itself, filling it with its dark mass of spores. On pressing the grain the spores become visible to the eye as a sooty and fœtid dust.

Of the cases in which Fungi are noxious to animal life, the commonest and most easily observed is that of the Empusina muscæ, *Cohn.*, to which so many house-flies fall victims. It is by no means a rare thing, especially during the autumn, to find flies with outstretched legs apparently glued to the window-panes, and surrounded by a white filmy cloud extending to a distance of one inch or two inches on each side of the body. This filmy cloud is a Fungus, which, generated within the body of the animal during life, has now forced its way out between the rings of the abdomen, and is spreading its filaments in every direction. [Recent investigations have brought to light the almost incredible fact, that this Empusina, when immersed in water, alters its whole character and develops into a plant, which was long looked upon as a Confervoid Alga (Achlya prolifera, *Nees*), (Plate XXIII.); a plant only too well known to keepers of gold fish, whose sides it clothes with numberless tufts of long colourless filaments, gradually wasting their powers and destroying their vitality. Nor does the wonder cease here: there is reason to believe, though the fact is not yet well established, that Achlya is but another form of Botrytis bassiana, the 'Muscardine,' to which I have already alluded as consuming the intestines of silkworms.—Ed.]

All the larger Fungi must be thoroughly dried before they can be put away with safety in the herbarium. With regard to the species which flourish on such compact material as branches, palings, &c., the simplest plan is to cut off so much of the wood as is convenient, and leave the preparation in the open air until the moisture has completely evaporated.

Fresh leaves and stems infested by microscopic forms of Fungi may be dried in the same way as the fronds of ferns or leaves of the Phanerogamia, of which more will be said hereafter. The only precaution necessary is, that the pressure be not too heavy, and that the blotting paper be constantly changed. As these Fungi arise, in the first instance, from below the cuticle in which they excavate (so to speak) little hollows, and then spread themselves around in yellow or black pulverulent masses, too severe a pressure may force them back into the cavities, or at least squeeze them against the plane surface of the leaf, and thereby destroy their natural habit and appearance. The reason why it is advisable to make frequent changes of the drying material is, that various forms of mould are developed wherever there is moisture present. This is of little consequence where large plants are being prepared, but may give rise to serious errors when the objects are of a microscopic nature.

The most difficult kinds to manage are the fleshy pileate Fungi, those, I mean, included under the order Agaricaceæ, or Hymenomycetes, of systematic authors. Numerous experiments have been made from time to time with a view to strike out some plan of retaining their natural form and features after death. But one arrangement after another has had to be abandoned, and mycologists have been compelled to fall back upon the earliest and withal the simplest method, that of drying them. Even this simple method, however, is not possible with the larger individuals, not only on account of their size, but because the substance of which they are composed is so sensitive to the influence of moisture, that it is hopeless to think of preserving them by any ordinary treatment. Under the most favourable circumstances they are shrivelled and shrunk out of all shape when taken from the press. So the student must be content with having portions only of the original plant at his command; but these may be prepared in such a way as to be full of instruction, if he will follow out the suggestions I am about to offer.

[But first of the parts which go to form an ordinary

Agaric (Plate XXIV.). On taking up one of these plants (or rather one of their fructifying organs, for the plant itself is concealed under the soil in the form of Mycelium) we see a convex expansion called the pileus or cap, supported by the stipes or stem, which itself rises out of the volva or wrapper, a tough membrane, which at one time enclosed the entire organism, but through which the pileus and stipes have forced their way, leaving only a fragmentary cup behind. The pileus, in fact, is a thick leathery roof, concealing and at the same time affording protection to the hymenium or reproductive organs; and, on turning the pileus over, we see that the hymenium is divided into numerous plates, the lamellæ or gills, radiating from the centre to the external border. Further investigations under the microscope reveal the fact, that these lamellæ are receptacles containing the sporules, the germs of the future Agarics. Perhaps it will simplify the matter to some of my readers if I add, that the pileus with its accompanying hymenium forms the edible portion of the common mushroom, the stipes usually going to form that useful sauce, 'catsup.' What are termed 'button mushrooms' are the young plants still imprisoned within the volva, or which have but just burst through its membranous coat.—Ed.]

In the first place, longitudinal sections must be made, traversing the whole organism, from the top of the pileus to the base of the stipes. To effect this, the operator takes a very sharp knife, or better still a razor, and with a firm hand makes a bold cut from above downwards right through the plant. This he repeats three or four times, so as to obtain successively several laminæ, each about two lines thick, presenting a kind of diagram of the different parts. These should be at once placed under the press. The quicker the operation of drying is performed, the finer will be the appearance of the preparation, and the better will the natural colouring be retained. This may be forwarded by frequently changing the paper, and by warming it before laying it on the object.

Of the two halves remaining over and above the portions cut away, the operator should separate the stem from the cap, and scoop out a large proportion of the hymenium, so as to leave the pileus entire with a certain amount of fleshy matter adhering to it. It might be better, perhaps, to remove the whole of the internal substance; but, in that case, the preparation would have a bad appearance, from being too transparent after it was dried. The remains of the stipes must be similarly treated; that is to say, a large portion of its interior must be removed, and then the fragments thus prepared are ready for the press. As soon as the pieces are all perfectly dry, one of the stems must be gummed or glued on white paper, and at its upper end one of the halves of the pileus fixed in like manner, so as to get, in fact, a more or less characteristic representation of the original plant. Where there is an abundance of specimens, the collector need not be so particular about preserving the two halves that have been already cut through. It is better indeed to dry the whole of a pileus, having first scooped out the greater part of the hymenium previous to fastening it on paper. When drying and gumming down the longitudinal section, pains must be taken not to disturb the arrangement of the lamellæ and their relation to the stipes.

The foregoing applies particularly to the very large fleshy Agarics. Those of a medium size may be simply divided through the centre of the cap and stem, and each half pressed and dried. The preparation is not very elegant, but gives satisfactory results from a scientific point of view. The smaller species, such as the Marasmii, Collybii, &c., require no special preparation beyond suspending them for some hours in a current of air (but not in the sun) until they have lost a portion of their contained fluids, and feel flabby and loose to the touch. They may then be submitted to the press as usual.

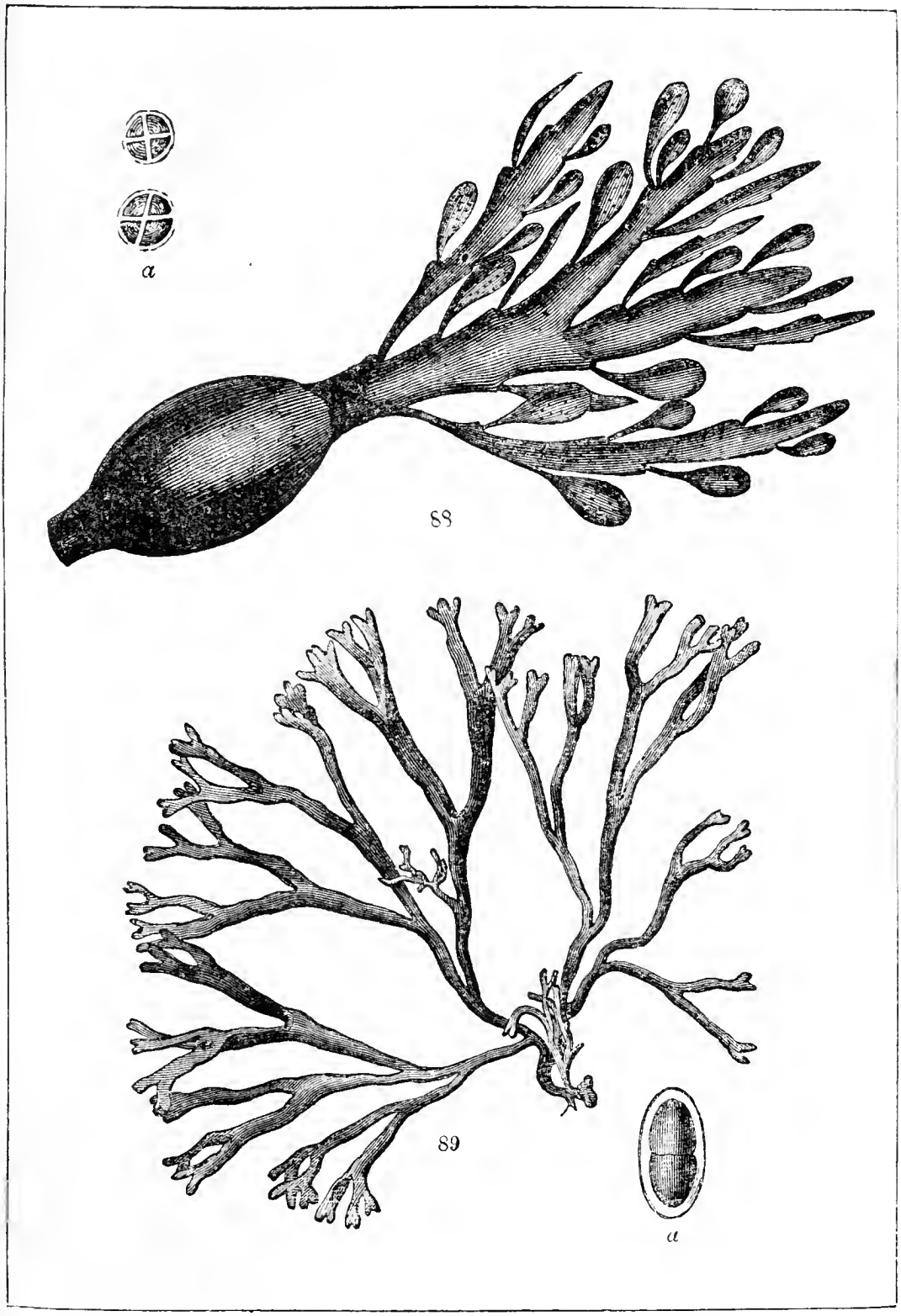
I should perhaps have mentioned before, when speaking of the very fleshy kinds, that all Fungi of a soft nature, like Mushrooms and Toadstools, should be hung up in the air

for at least twelve hours before being operated on. The work itself is rendered much easier, and there is less chance of the delicate parts being mangled.

Small coriaceous Fungi (the Polypori, Thelephoræ, &c.) must not be weighted too severely. There are some kinds of Fungi, which are as hard as wood; from such thin sections may be taken in various directions, and put away at once. Several species belonging to the genera Peziza, Hirneola, &c, are of a totally different consistency, being strictly gelatinous. These will partially recover their original form and appearance on being moistened, long after they have been deposited in the herbarium.

As a final process, subsequent to the pressure and drying, every portion of the Fungi—of the leathery and fleshy kinds, I mean—must be impregnated with corrosive sublimate, to save them from the attacks of insects. But with regard to this I will speak more freely when treating of the herbarium, and the best method of preserving its contents uninjured.

However well prepared, dried Fungi, especially the pileate group, are very difficult of determination. If, therefore, from want of time or leisure, the student is unable to submit his freshly gathered examples to a rigid examination, he should at least assist his memory by making a note of such characteristics as come under his eye before the plants are dried. The main points to observe are these: the colour of the stem and of the upper surface of the pileus; consistency of the fleshy substance, whether hard and brittle, tough and gelatinous, soft and spongy, &c.; the odour emitted, of garlic, of violet, of putrid flesh, &c.; the presence or absence of a milky fluid when fragments are broken off; and, lastly, the changes of colour, which take place when the plant is freshly cut. For a more scientific diagnosis it is necessary to ascertain, what relation the reproductive parts hold to the general structure of the organism; whether, for instance, the spores are imbedded in lamellæ (as with the Agarics), are borne in tubes on the lower



88. Fucus nodosus. *a*. Spores.

89. Fucus canaliculatus. *a*. Spores.

part of the disc (as in the Polypori), or whether they cover the top and sides of a club-shaped receptacle (as in Clavaria, &c.). The spores themselves should also be secured as useful aids. This may be done by laying the fructifying organs on a piece of white paper, and leaving it undisturbed for about twenty-four hours. On lifting it at the end of that time the paper will be seen to be sprinkled with a brown (occasionally white) dust, which is in fact a multitude of ripe spores: these may be wrapped in paper, or shaken into a corked tube for future examination.

I strongly advise the young mycologist to make drawings of the Fungi, or at least of the principal forms, which come under his notice. Even if he is not a practised draughtsman, he can by perseverance soon acquire skill enough to copy their outline, and lay on the proper colouring: however roughly done, he will probably find his sketch of considerable use in the comparison of individuals and the determination of species. The systematic examination of these plants cannot be carried on without the aid of the microscope, on account of the extreme minuteness of their organs. In some instances an ordinary needle attached to a wooden handle is sufficient to expose their inner structure: generally speaking, however, the cellular tissue and organs of fructification cannot be properly seen unless a delicate section is made with a razor. With such as rest upon a stout, firm base, like the branch of a tree, there is no difficulty; a little practice will enable the student to make a clean cut from end to end. The same may be said with respect to the Agarics and other soft, fleshy kinds: in these a section may be easily made through the pileus, so as to include the hymenium. On the other hand, species which are parasitic on the leaves of Phanerogamia must be treated in a different way. The leaf itself, not giving sufficient support to the cutting instrument, must be laid between two pieces of cork—a common wine cork divided longitudinally answers perfectly well; then, by cutting

clean through cork and leaf, sections of the required thinness may be obtained without difficulty. To keep the two pieces of cork from shifting during the operation, they may be thrust through a metal ring of suitable size, or a piece of stout paper may be gummed round them; a still simpler plan is to tie them together with strong thread or thin string. The section can be placed at once on a slide with a fine hair pencil.

In a large number of cases the fruit must be examined in a dry state, in order to ascertain the true connection of the spores with their receptacles, as water causes them to separate. Of this description is the whole order of Botrytaceæ or Hyphomycetes—an order which embraces most of the common 'moulds,' growing upon organic substances, both dead and living; the Peronospora of the potato, to which I lately alluded; the parasites which infest the onion, pea, rose, and clover, and numerous other pests of the farm and garden. In all these (which to the naked eye appear as patches of a white woolly substance) the fruit, or acrospores, as they are called in technical language, are situated on the tips of certain upright threads, sometimes solitary, but more generally branched, so as to have the appearance of miniature forest trees, only that there are no leaves, and that each branchlet supports at its apex a single round or oval acrospore. In some cases the branchlet itself is moniliform, or made up of rows of these tiny reproductive organs, adhering end to end.

From some unknown cause, the 'pedicels' no sooner come in contact with water, than they 'lose their heads;' the fruit drops off, and the observer misses the chance of ascertaining the way in which pedicel and acrospore were united. If then a fluid is applied at all, a single drop must be laid on the slide after the specimen has been placed ready for examination. Let the water touch the covering glass, and it will creep under by capillary attraction and saturate the object.

The following re-agents may be used with advantage in the examination of the spores — sugar, sulphuric acid, iodine, and caustic potash, in solution. [As to the method of employing re-agents, I must refer the student to the works of Dr. L. Beale and others, bearing more directly upon the subject than this little work pretends to do.—Ed.]

CHAPTER XIII.

OF THE LICHENS.

JUDGING FROM external appearances and from their natural habits, no two groups of plants would seem to be more distinctly separated than the Fungi and the Lichens. Their boundaries, one would suppose, are as sharply defined as any embraced under the great family of Cryptogamia. Nevertheless, modern authors are gradually drawing to the opinion that, sooner or later, the Lichens must be reduced to mere forms of the Fungal class. The point on which the 'Separatists' have mainly relied is the presence, in the thallus, of globular gonidia, containing a green matter in the cells, which gonidia are supposed to be wanting in the Fungi; but it is certain that some of the Lichens (Abrothallus for example) are destitute of green gonidial cells. And it is by no means certain that some analogous structure is not to be found in many of the Algæ. Agardh considers Lichens more nearly allied to Fungals than to Algals: he remarks, that 'if Sphærias, or Pezizas, had a thallus, they would be Lichens; and that the same part is all that determines such genera as Calycium, Verrucaria, or Opegrapha to be Lichens and not Fungi.' (Lindley, 'Vegetable Kingdom,' 47.)

However, leaving these matters to be discussed by physiologists, we will assume for our purposes, that the distinction ordinarily laid down in regard to the two classes is correct, viz. that 'while the Fungi have their vegetative structure immersed in the medium in which they grow, the Lichens are entirely aërial encrusting plants.

A practical matter of great importance to the collector, though of no value in the eyes of the systematist, is the

admitted fact, that no Lichen is ever submersed, and that they are never developed in mines, caverns, or places deprived of light. In this respect they form a striking contrast to both Algæ and Fungi; the former, as we know, depending for their very existence on the presence of water, while the latter love moisture, and the absence of direct sunlight.

Lichens, however, prefer the driest and most exposed localities. Within certain limits they bear, with equal indifference, the scorching heat of the midday sun and the icy breath of the north wind. Even when so dried and withered as to crumble in the hand, they will wake to new life when again moistened and placed in such conditions as allow of the development of their cells. This extraordinary persistency, the power of retaining life under circumstances which would be fatal to any other organised being, causes the Lichens to be veritable pioneers in the vegetable kingdom. Taking possession of the bare face of a cliff, where not even a moss could find footing, they seize the passing dew or raindrop, introduce it into the shallow fissures of the rock on which they are clustered, and thus gradually prepare a foothold for the higher plants. Nor is their usefulness limited to their living state; their very death is made subservient to the great purposes of nature, by filling the cavity on which they grew with the humus formed out of their own corruption; doubtless a trifling amount, but sufficient to support the tiny moss which succeeds them, and which in its turn lives and dies only to supply nutriment for some more highly organised plant. Perhaps the most remarkable evidence of the powers of vitality belonging to this class is shown in the fact, that no sooner do the streams of lava begin to cool after a volcanic eruption, than a Lichen (known as Stereocaulon Vesuvianum) spreads its hard solid thallus over the glowing surface.

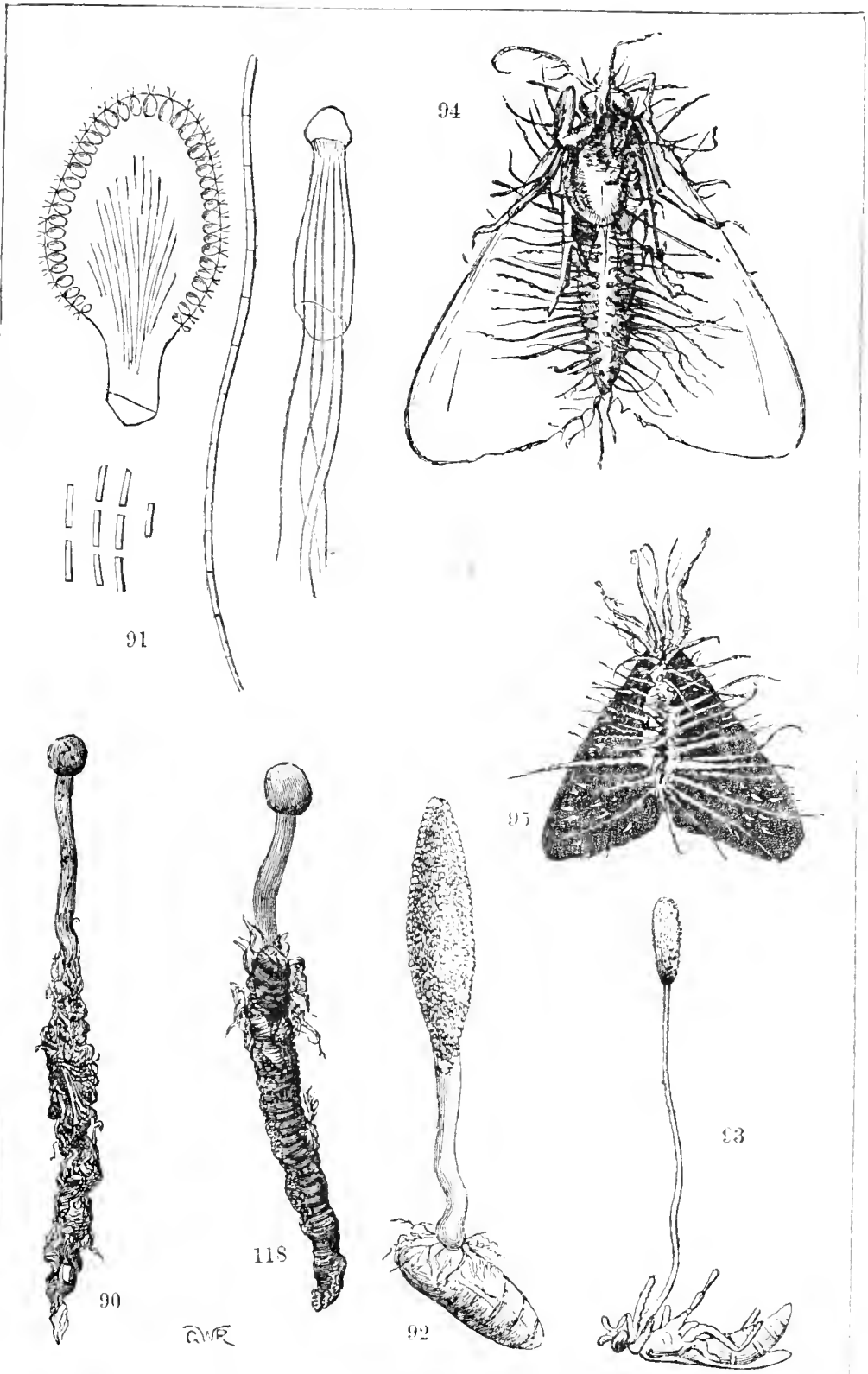
Most of the Lichens prefer to grow on either stone or wood; very few flourish on the naked soil; a small propor-

tion are parasitic, either on other Lichens (as Abrothallus), or on the leaves of box and similar evergreens (as Strigula) The collector may hope to get his best gatherings from stone and brick walls, trunks of trees, palings, and posts, all of which are often clothed with an immense variety of these plants, especially where they have a northern aspect. Many of the species are exceedingly minute and of so dark a colour, as not to be easily distinguished at a short distance from the bark on which they rest. In fact, tree stems and palings must be as diligently searched for Lichens, as the leaves and stalks of herbaceous plants for microscopic Fungi. The same outfit is requisite here as was recommended in the last chapter, with the addition of a couple of chisels (pointed and broad) and a hammer for detaching the species which grow on the surface of rocks.

Those kinds which are more or less free (that is to say, in which the thallus is not wholly fixed down to the object on which it grows) may be simply taken off by hand, and, if not too dry, placed between the leaves of a book. It is best to gather them when they are damp; consequently, the fittest time for searching for them is after rain, or in the early morning before the dew has passed away. Botanists, however, cannot always time their excursions so nicely as to meet these circumstances exactly. When this is the case, and the specimens on being gathered feel dry and brittle, they must be dipped in water, and suffered to imbibe so much of the fluid as to render them limp and flexible. After this, allowing the surface moisture to evaporate, they may be safely carried in the book, or wrapped in paper, in the pocket.

I may as well observe here, that most of the Lichens, which are of a light grey tint when dry, become much darker, and frequently quite green, when moistened. I mention this that the beginner may not be disappointed, and attribute to his unskilful preparation what is in fact a natural change of colour.

On being brought home the specimens must be looked



90. Torrubia entomorrhiza.
91. Section, &c.
92. Torrubia militaris.
93. Torrubia gunnii.
94. Torrubia sphingum.
95. Torrubia sphingum. Isaroid condition.

over, and, when necessary, again damped and softened. They should then be spread out between sheets of blotting-paper, so as to exhibit as near as can be their original character, and left to dry under a light pressure. On the whole, the Lichens cause less trouble in their preparation than any other group of plants, except perhaps the Mosses.

In the case of certain small species (as, for instance, Bœomyces roseus) which grow on the earth, the better plan when collecting them is to carry away with the plant a thin layer of the soil itself. This is easily effected by means of a knife. In the same way all such as flourish on wood, tree stems, palings, &c., should, on being taken off, retain a very thin section of their support. The difficulty of gathering those which are firmly fixed to the face of a rock, overgrowing it like a thin crust, is far greater, as the stone itself must be chipped off with chisel and hammer. Of course the difficulty is increased where the operator has to deal with the smooth surface of a compact rock; as, on the other hand, it is considerably lessened when the material is of a calcareous, slaty, or schistose character. Each piece, on being broken off, must be wrapped separately in paper, to prevent them from rubbing against one another, thereby spoiling the incumbent Lichen, or at least destroying its fruit.

I take this opportunity of cautioning the botanical novice against preserving only such small specimens of the chipped-off rock as will lie between the sheets of his herbarium; an error he is liable to fall into for the sake of uniformity and for convenience of arrangement. He forgets that, as time goes on and his collection increases, it must of necessity be divided into numerous smaller portions, and be put away in drawers or boxes. He had, therefore, much better at once secure good instructive examples, even though he is obliged to keep them in separate repositories, than have to do his work over again at a future period.

I need scarcely perhaps add that, with Lichens, as with

any other form of plant, those are the most instructive examples in which the organs of fructification are well displayed. As regards the Lichens, indeed, the presence of the fruit is indispensable.

Investigation into their minute structure is accomplished, as in the case of the Fungi, by means of thin sections, cut through both frond and receptacle.

CHAPTER XIV.

OF THE MOSSES AND THEIR ALLIES.

The Mosses occupy a less exclusive position than the preceding classes of the Cryptogamia, inasmuch as in many respects they approximate to the great family of plants, the Phanerogamia. [Not that there is any likeness to a 'flower' in their organs of fructification; so far there is still a wide gulf between the highest of the 'Muscal alliance' and the lowest of the sexual plants: nevertheless, when we come to examine their structure, we find that among Mosses a great step in advance has been made in the scheme of nature. For the first time now we have to deal with a true root, a true stem, and true leaves; though it must be owned, that in a few instances it is a work of some difficulty to detect these organs. Thus Buxbaumia aphylla has received its specific name from the apparent absence of leaves, and the species of Sphagnum retain their roots only in the young state. For the first time, too, we meet with traces of that special characteristic of the more highly organised plants—a vascular system.—Ed.]

With regard to the localities in which the Mosses delight to dwell, we find them to be truly cosmopolitan. The particular species are by no means indifferent to the situation they may occupy; but, taking them as a whole, the members of this order exist wherever shade and moisture are afforded; the actual species varying according to the nature of the soil, and the material on which they grow. Streams and morasses have their peculiar species. Fontinalis, Sphagnum, &c., are strictly aquatic; and from these we may trace them, step by step, to the sloping sides of a ditch, the weather-beaten roof of a thatched cottage, the

refts in a wall, the hard surface of a rock, and finally to spots (such as the resort of the charcoal-burner) where the soil, though sheltered by trees, has been withered and scorched by the action of fire.

Mosses, observes Lindley, 'are found in all parts of the world where the atmosphere is humid, but they are far more common in temperate climes than in the tropics. They are among the first vegetables that clothe the soil with verdure in newly formed countries, and they are the last that disappear when the atmosphere ceases to be capable of nourishing vegetation. The first green crust upon the cinders of Ascension consisted of minute Mosses; they form more than a quarter of the whole Flora of Melville Island; and the black and lifeless soil of New South Shetland is covered with specks of Moss struggling for existence.'

Their favourite localities, however, are those which are rich in decaying vegetable matter, and but little exposed to the sun's heat; so that it is to the wood and forest, the deep ravine and the narrow valley, that the collector must look for his principal gatherings. The shady side of bold ridges must be carefully searched; also damp hedgerows and wet rocky places, especially with a northern aspect, for in these many of the delicate Jungermanniæ love to grow. A few, comparatively rare, forms (the Splachna) choose the dung of animals as their habitat, principally in Alpine and Subalpine districts. 'One of these, Splachnum angustatum, which is commonly met with upon dung, we once saw growing vigorously upon the foot of an old stocking near the summit of Ingleborough, Yorkshire. The same species was found by a friend of ours covering the half decayed hat of a traveller who had perished on the mountain of St. Bernard in Switzerland; and the same, if we mistake not, was discovered by Captain Parry in Melville Island, vegetating in the bleached skull of a musk ox.'* The Sphagna, as stated above, are truly aquatic,

* Muscologia Britannica.

choosing by preference the swamp and morass, great tracts of which they cover with their spongy tufts. They may be easily distinguished, even at a long distance, by their singular pale yellow hue, so different to the bright rich green which generally marks the Moss tribe. The denizens, however, of the water are far inferior in number to those which draw their nourishment from the atmosphere, thriving on the surface of rocks, damp walls, and stems of trees. Thus the Orthotricha are almost entirely confined to the latter habitat, the exceptions occurring on rocks, never on the naked soil. The collector, therefore, must take a rigid survey of the trees, as well as of the ground which they overshadow, taking particular care to examine the hollows formed by the junction of the branches with the stem; also the base of the tree where the latter passes into the root and buries itself in the soil; for it is in places of this description that the rain and dew settle, and consequently Mosses are encouraged to develop themselves. Uprooted trees, on which time and the weather are beginning to make an impression, are also favourite localities for nearly all the members of the Muscal alliance. Let them be closely investigated, for, other conditions being auspicious, more examples will often be gathered here than hours of research will disclose in many less-favoured spots.

A strong knife, a waterproof bag or small tin vasculum, a few small bottles, and a supply of paper, are all that is necessary, by way of outfit, for a 'ramble among the Mosses.'

If possible, only such specimens as are in full fructification should be gathered; for, as a practical matter, mere tufts of leaves without signs of fruit, or with immature fruit, are really of very little value. So important is this, that, should the collector find himself in a neighbourhood where the Mosses do not yet display their fruit, he had far better leave them for a while, than gather them at once, however tempting the opportunity, or lovely the specimens. Let him mark the place carefully, and revisit it in a month or two, and in all probability he will be amply rewarded

for his self-denial. Of course there are cases in which he has but little chance of seeing the spot a second time; there is no help for him then but to secure the prize while he can. There are a few cases too in which the plants rarely, if ever, develop their organs of fructification. Here again he must 'take things as he finds them;' it would be of no use to wait, and he must be satisfied with sterile examples.

[The reproductive organs of Mosses consist of so-called antheridia and pistillidia, or archegones. The former are minute globular or oval bodies, supported on a short pedicel, and, when ripe, discharging a granular matter, which has been likened to pollen. They are usually associated with a number of jointed cellular filaments or paraphyses, the 'fila succulenta' of Hedwig. These antheridia are considered to be the representatives of the stamens, or male organs of the flowering plants. The pistillidia, on the other hand, minute flask-shaped bodies, swollen at the base, are looked upon, as their name implies, as corresponding to the pistils, or female organs of the Phanerogamia. By degrees they are developed into the long stemmed capsule, or theca, so conspicuous in most Mosses by their bright chestnut colour.

Now it is requisite, if possible, that the student should provide himself with examples of each of these organs, not only because of the interest attached to them, but from the increasing tendency of muscologists to base their systems of classification on these minute structures.—Ed.]

It frequently happens, however, that Mosses are diœcious; that is to say, the two kinds of reproductive organs are situated on separate plants, the mature female of course being the most conspicuous. This is exactly analogous to what occurs among the true sexual plants; but then their parts, as a rule, are evident enough, whereas among the Mosses and their allies the same parts, at any rate at first, are strictly microscopic. All we can recommend to the student is, to make diligent search. If the antheridia are not to be found in the 'pistillidiferous' specimens, he should

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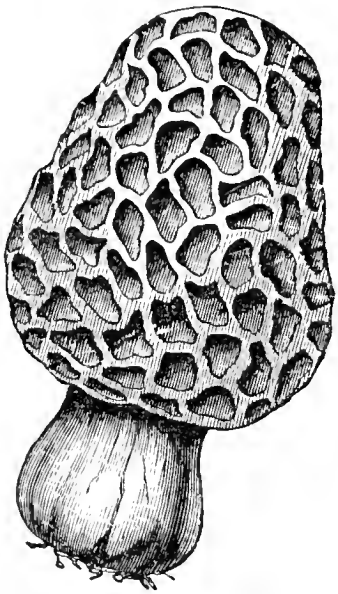

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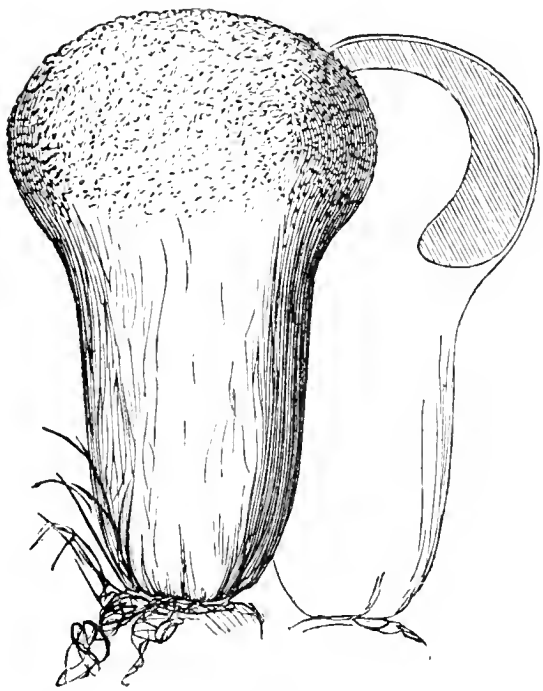

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96. Torrubia sphingum, fertile stipe.
97. Torrubia stylophora.
98. Morchella esculenta.
99. Lycoperdon gemmatum.

examine the neighbourhood (especially where it varies a little in elevation or dampness) for male plants. 'Practice makes perfect,' and though frequent disappointments may occur, success will follow, in a greater or less degree, as he applies himself more vigorously to his work.

In gathering the Hepaticæ it is indispensable to secure the organs of fructification: these are of simpler structure and lower organisation than in the Mosses, consisting of capsules either imbedded in the thick cellular frond (the Ricciæ), or elevated on footstalks (Marchantia, Jungermannia, &c.), but in either case unprovided with the calyptra and operculum, the hoods which distinguish and protect the spore cases of the true Mosses. When then the latter plants are placed in the bag or vasculum, precautions must be taken against losing the hoods, as they are of great service in the elucidation of genera, and unhappily they are very apt to drop off—[I always myself 'bottle' a few small specimens, the enclosed moisture preventing the separation of the calyptra from the theca. The leaves too are kept fresh and the plants generally are saved from rubbing and consequent mutilation. This refers more particularly to the Jungermanniæ, the extreme delicacy of whose fruit, and stem, and leaves demand most tender treatment. The 'bottling' also ensures a specimen being ready for examination immediately on returning home; though this is by no means essential, as all the Moss tribe speedily recover their plumpness and general appearance, on being immersed in water, after they have been long dried.—Ed.]

They are very easily prepared for the herbarium, all that is necessary being to separate them into convenient portions, pick out all foreign bodies (such as fragments of leaves, &c.), place them between blotting-paper, and submit them to the press. The weights employed must be of the lightest, as otherwise the natural appearance of the plants are distorted. The true Mosses are usually divided into two chief sections—the Acrocarpi, or those in which

the fruit is situated at the summit of a stem, and the Pleurocarpi, which bear the fruit on the sides. In one word, in the first, the theca or capsule is terminal; in the second it is lateral. This difference of structure necessitates a difference of treatment in preparation. Bunches of the lateral fruited species may be separated by the hand without taking the trouble to isolate individual plants: it is better, in fact, to leave them massed together, as showing their character of growth more accurately. With the terminal fruited species, on the contrary, the natural habit of the plants is seen better if they are separated, though they need not be entirely so. For this purpose, two or three clean cuts may be made with a knife through the tuft, from above downwards, thereby making thin sections held together slightly at the bottom, either by the adherent earth, or by their own interwoven roots.

Some of the very delicate kinds, such as Brachyodus or Seligeria, and many of the Jungermanniæ should be collected together with the bark or stone to which they have attached themselves.

The Hepaticæ need great care in their preparation; not the least difficulty is the getting rid of the soil from their roots without injuring the leaves or breaking the stem. The best method of accomplishing this is to lay the plants, just as they are brought home, in a cup of clean water, then, by a gentle movement of the fluid backwards and forwards, the earth will gradually separate itself and settle at the bottom. The water should be constantly renewed, until no signs of discoloration appear. Next let the plant be carefully lifted out of the cup and laid on soft paper to allow of the water draining off. Here, again, great care is needed, because some of the important parts are easily broken off and lost from their extreme minuteness, if any roughness or over-haste is used; such are the so-called gemmæ, the calyx or vaginule, and the antheridia, on their short pellucid footstalks.

An ordinary lens is sufficient for the examination of the stems and branchlets of the Mosses; but the construction of

the leaf (especially in the Hepaticæ) can only be properly seen with a microscope whose powers are not less than 200 diameters. For this purpose a leaf must be separated, by means of a pair of forceps, quite close to the stem, or the stem itself may be divided above and below the point of attachment, and the whole section submitted to the microscope. This last is perhaps the better arrangement, because it often happens that the base of the leaf is furnished with peculiar cells, which are of service in discriminating species. A drop of water should be added to the leaf, when it is laid on the slide, as this renders the delicate network of cells more pervious to light.

I have found the following plan bring out the form of the cells of the Jungermanniæ, and indeed of many of the Mosses, very clearly. First, let the leaflet be warmed to ebullition in a solution of caustic potash, rinse it in soft water, and then add a drop of a solution of chloride of zinc and iodine. By this means the cell walls, after a while (though sometimes not for hours), assume a blue tint, and on being slightly pressed under the covering glass, the layers of cellular tissue exhibit themselves to great perfection.

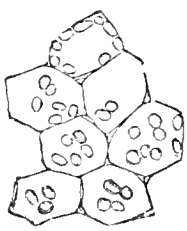
The arrangements, however, of the leaf cells may be best seen in vertical sections, made by means of a divided cork in the way recommended at p. 129. In many cases the necessity for preparing these thin sections is not called for, while in others (as Fissidens, Polytrichum, Sphagnum, &c.) the true construction of the leaf cannot be made out without them.*

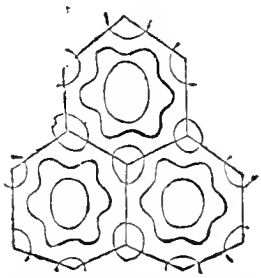
* The following observations on the leaves of the Jungermanniæ are of value:—'The leaves are remarkably varied in their form and arrangement, and usually afford excellent guides in the discrimination of one species from another. A glance at the figures which follow will show their great variation in this particular. . . . In all cases the leaves are without footstalks, and in each British species alternate; that is, they are not arranged in pairs at the same level on the stem, but one is always a little above or below its nearest neighbour in its attachment. In some cases they are ranged in two rows

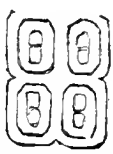
The amphigastria are a kind of modified leaves in the Hepaticæ, answering in some respects to the stipules of more perfect plants. Growing, as they do, on the lower surface of the stem, and being very minute, considerable trouble is involved in searching for them, as numerous stems have to be examined; neither are they always present over the whole extent of the stem. The most likely parts are healthy young shoots, especially those that support the reproductive organs. The eye, too, should be directed to the *sides* of the under-surface, rather than along the central axis. For the purpose of examination the amphigastriæ may be shaved off with a thin and very sharp penknife, or the stem itself may be divided, as directed for the true leaves. The latter method has the advantage of securing the stipule from injury, and of giving a good insight into its mode of attachment.

on opposite sides of the stem. In other and fewer instances they are attached to, or grow from, all sides of the stem. It is of rare occurrence to find the leaves notched at the margin, but this sometimes takes place.

The cells, of which the leaves are composed, are roundish, or hexagonal, from pressure, and very variable in size. This also is a great assistance in the determination of species. . . . The cells of the ladder scale Moss (Alicularia scalaris), for instance, contain peculiar nucleate bodies of from two to four granules in a line in







each of the cells (fig. 2); those of the three-toothed scale Moss (Plagiochila tridenticulata) fig. 3, and of the curled-leaved scale Moss (Jungermannia curvifolia), fig. 4, will illustrate some of the forms of leaf cells.' ('British Hepaticæ; an Easy Guide to the Study of,' by M. C. Cooke—a work which may be consulted with advantage by the student. It is crowded with figures, and its exceedingly low price places it within every one's reach.)—Ed.

The vaginule. which answers to a certain extent to the calyx of the Phanerogamia, at first encloses the spore-case ; the latter, however, soon bursts through its cellular envelope, and is elevated on a delicate threadlike stem. The vaginule should be examined in its early state, previous to its losing its contents, first from the exterior ; and, when its outward form is familiar to the observer, he should divide it under water into two halves longitudinally, in one of which he will see the organs of fructification in a greater or less degree of development. Ordinarily this division of the vaginule may be easily effected by means of a forceps in each hand ; occasionally it is of so fleshy a nature as to allow of being cut with a knife.

For studying the anatomical structure of the fruit of the Mosses a capsule must be taken with the fruit not yet ripe. Thin sections, vertical and horizontal, may be made with great ease. A peculiar organ is found in the capsules of nearly all the Hepaticæ, called the elater. It is a single or double filament, spirally twisted, and enveloped in a slender tube : both tube and elater form interesting objects for the microscope. Of what service the elaters may be in the economy of the plant is not yet accurately ascertained ; their probable office is to disperse the spores by their elastic movement as soon as the latter are ripe.

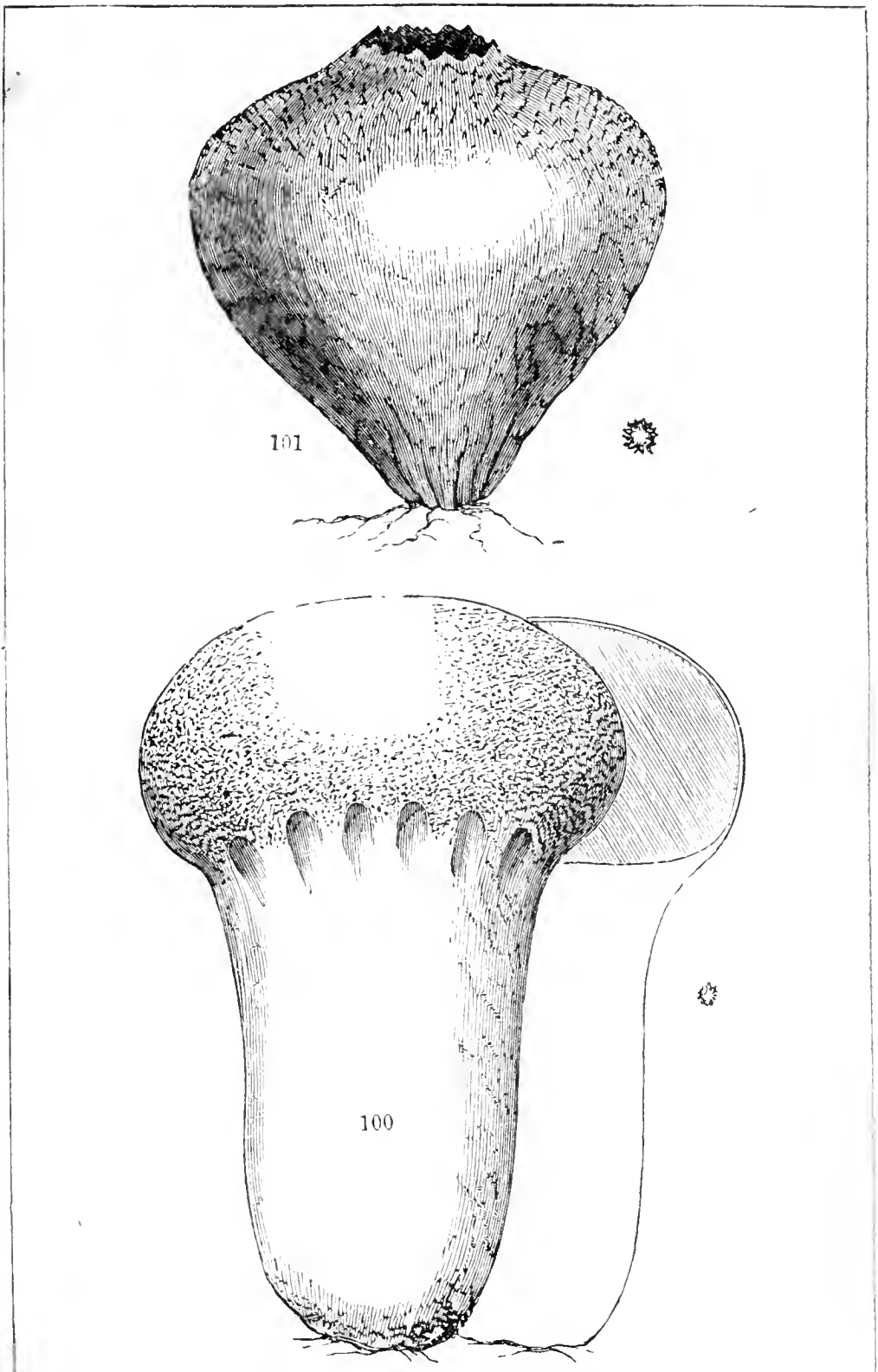
A still more mysterious organ found in the antheridia of most of the Mosses is the spermatozoid, or antherozoid, or spermatic filament ; for by all these names it is known among botanists. It is a minute thread, of which the functions are not yet known. On being placed in water these spermatozoids exhibit active spontaneous motion, as may be seen by squeezing the contents of a ripe antheridium into a drop of water on a slide, covering it with thin glass, and then submitting it to a microscope with a power of from 300 to 600 diameters. If the movements are too quick for observation, they may be retarded by allowing a drop of iodide solution to make its way under the covering glass.

For the determination of species the capsule and its enclosed spores must be quite ripe, and must still retain its operculum (or lid), and calyptra (or veil). A few species (as Phascum) are destitute of an operculum; and in some (as Sphagnum) the calyptra disappears long before the capsule reaches maturity. In all cases however, where they are present, both lid and veil drop off as soon as the spores are ready for dispersion; an office which is greatly assisted by a third organ, which crowns the capsule, and is known as the fringe or peristome.

This last, which is sometimes single and at others double, is of the utmost importance in the discrimination of genera; so much so that, in systematic works, the characters of the subsections are founded on its absence or presence; and the Aploperistomi (plants with a single fringe), the Diploperistomi (those with a double fringe), and the Gymnostomi (or such as are destitute of a fringe), form acknowledged divisions in the Muscal family.

The peristome, moreover, from its peculiar construction and delicate colouring, makes a lovely object for the microscope. A specimen is easily prepared: lay the capsule on the thumb-nail of the left hand and cut it across the shorter axis with a sharp knife, rather towards the summit. The upper portion, which now represents a short tube, is next to be cut half through vertically. The fringe may then be spread out on a slide and covered with a thin glass to prevent it from again curling up.

The leaves may be preserved for future observation by laying them between two pieces of thin glass, united at the edges by asphalte. When wanted for use the specimen is dipped into water, which entering between the glasses moistens the leaf, and restores it temporarily to its original appearance. All the more important organs may be treated in the same way. By this arrangement much time is saved, when it is desired to examine any particular species, of which perhaps there may be but few examples in the herbarium, and the specimens themselves, preserved



100. Lycoperdon saccatum.

101. Lycoperdon atropurpureum.

between the sheets of paper, are saved from the wear and tear to which they would be subjected if constantly brought out for investigation.

I am of opinion, that if the specimens were mounted in silicate of potash (or waterglass, as it is sometimes called), much future time and trouble would be saved, as the leaf would probably retain its fair appearance without being immersed in water every time it was wanted. But my own experience is not sufficient to justify me in recommending it to others. [I have frequently employed silicate of potash as a preservative medium for the leaves of Mosses and other objects. In some instances it has succeeded thoroughly, the leaflets retaining their fresh appearance, and remaining unaltered. But it appears to be uncertain in its action, 'vacuoles' and bubbles often appearing in its midst in the most unaccountable manner. For pleasantness in using, rapidity in drying, &c., it surpasses any medium with which I am acquainted.—Ed.]

CHAPTER XV.

OF THE FERNS AND FLOWERING PLANTS.

I HAVE thought it as well to unite these two classes, not only on account of the external resemblance which they bear to each other (as compared with the preceding families), but because, speaking generally, the same methods of preparation are applicable to both. As a rule, Ferns, especially the commoner sorts, are far better known to the botanical student, than any of the Cryptogamic orders, not excepting the Algæ. Their bright green colouring and the graceful outline of their fronds invite the attention of the passer-by; and many a beginner glories in a collection of dried Ferns, who has never troubled himself about their specific or even generic differences. These depend almost exclusively upon the fructification, the absence or presence of an indusium, the form of the spore-case and its ring, and the shape of the sorus or collected spore-cases. It would be beside the object of this Handy-book to enter into this subject, nevertheless the accompanying plates (XXV. and XXVI.) will assist the student in discriminating some of the genera more commonly met with; the glossy Hartstongue (XXV. 110), and scaly Ceterach (111), the glorious flowering Fern (XXVI. 112), and its humble relative the Adders-tongue (113).

For a more intimate knowledge of the structural differences in this interesting family I must refer the reader to John Smith's 'Ferns, British and Foreign,' and to the works of Newman, Moore, and other well-known Pteridologists.

If it were necessary to warn the student to secure perfect examples of the more lowly organised plants—the Algæ, Fungi, Lichens, and Mosses—still more needful is it to

repeat the warning here. Among the Phanerogamia, with very rare exceptions, flower and fruit, leaves, stem and root, are fully developed; and (excluding the first-named) they are equally perfect in the Ferns. Consequently every one of these organs ought to find a place in the herbarium. There is no positive reason why the stem, or the root, should be neglected any more than the flower, or the leaf. And yet this is just the point in respect to which beginners make the most woful mistakes. They are satisfied with a moiety, when they should have the whole. An herbaceous plant, for instance, is plucked off at some distance above the junction of the stem with the root, and carried triumphantly home as a specimen of that particular species. What is the result? Suppose it is an Orchis which the tyro has in hand. He searches through one or the other of the standard botanical works, and, under the head of Orchis, he finds that the specific differences depend in a greater or less degree on the form of the root: thus, while one important subdivision has 'tubers undivided,' another is provided with 'palmate tubers.' Hence he is reduced to guess at the name of his fragment, or at best to do his work of collecting over again—not always a convenient task.

The fact is, there are peculiarities in every part of a plant, from the root to the inflorescence, which cannot be neglected with impunity. What a large number of species depend for their due identification upon the presence of the radical or root leaves, and which cannot be satisfactorily determined, unless these are under the observer's eye! The very names of some are based upon the fact of the root-leaves having a totally different form to the series which clothe its upper parts. It is well known that the stem-leaves of the common hare-bell are narrow and linear. Whence then its technical name, Campanula *rotundifolia*? It was given to it by the great Linnæus, who saw it in the early summer forcing its way through the chinks of some stone steps in the university of Upsal. At that season the

crown of the root is encircled by round or cordate leave which quickly decay and vanish; hence the origin of its specific title.

Here then is a case in point, illustrating the need of gathering examples of all the leaves, radical and cauline alike.

There are certain families also, like the Roses and Brambles, in which the leaves vary much in form according to the part of the plant on which they grow. Specimens of these variations must be gathered, if the student hopes to have at all a satisfactory collection.

Where the plants are either monœcious or diœcious, it stands to reason that both the sexes must be secured, whether found on separate individuals, or on different parts of the same plant.

The fructification plays a most important part among both generic and specific characteristics. What, for instance, is the value of a flower, taken alone, among the Cruciferæ and Umbelliferæ? Almost *nil*! It is to the fruit that we have to look to bring order out of chaos, and settle the limits of genera. In a modified degree the same may be said of other families.

As many species flower through a large part of the year, there is seldom any difficulty in securing with the flower the half-developed fruit, which should be noted down and again visited at a later period, when the seed-vessel is mature. The Cruciferæ, except in their earliest stage, are tolerably certain to supply the collector with both flowers and fruit—the latter in a more or less advanced condition—the ripest at the base of the stem, and so passing through every stage up to the barely opened corolla.

Another group of plants, which has to be carefully watched, are those trees and shrubs in which the flowers are produced on naked branches, the leaves not appearing until some time after the flowers themselves have withered away. Of course, in such instances, flower and leaf must be gathered on different occasions. Only let the collector be careful to take the latter from the same specimen, from

which he has already gathered the flower. The same foresight must be extended to the fruit. The latter, indeed, is not indispensable, though certainly desirable; for the reader may easily picture to himself what confusion and errors may possibly arise, where there is no certainty of the examples, which lie together in the herbarium, having been the produce of the same plant.

The above remarks refer with tenfold force to the Willows, which seem to have a peculiar facility for hybridising; and, therefore, the greatest care should be taken to isolate every specimen, and if possible to have it in one's power to identify the very tree from which each was taken.

The Ferns are no exception to the rule, which demands that the plant should be seen in its integrity when dried. The crown and root must always, if possible, be secured as well as the frond; and of the latter, those which have no fruit on them must not on that account be passed by, as the two kinds often exhibit wide differences in form, and mark the character of the plant. More than one species of the remarkable genus, Equisetum, is furnished with both sterile and fertile fronds; both of which must of course be gathered and laid side by side in the herbarium. In the case of the common Equisetum arvense, the succulent, fawn-coloured, fruit-bearing stem rises upright from the soil weeks before the harsh green procumbent frond spreads itself over the ground. In others again the fertile shaft is entirely unbranched, while the sterile stems are enriched by frequent whorls of elegant pendant branches. The two sorts of frond may be easily recognised; while the barren stem tapers gradually to a point, the fertile is furnished with a stout clavate head, which is in fact the receptacle, and contains the spores in a number of separate sporangia. These spores are themselves very interesting objects: each is furnished with four filamentous processes, known as elaters, though very unlike the elaters which are mingled with the spores in the capsules of the Hepaticæ. They are extremely sensitive to the influence of moisture,

and, if breathed upon while under the microscope, will be seen to curl and uncurl themselves, enfolding the spore or causing it to dart on one side.

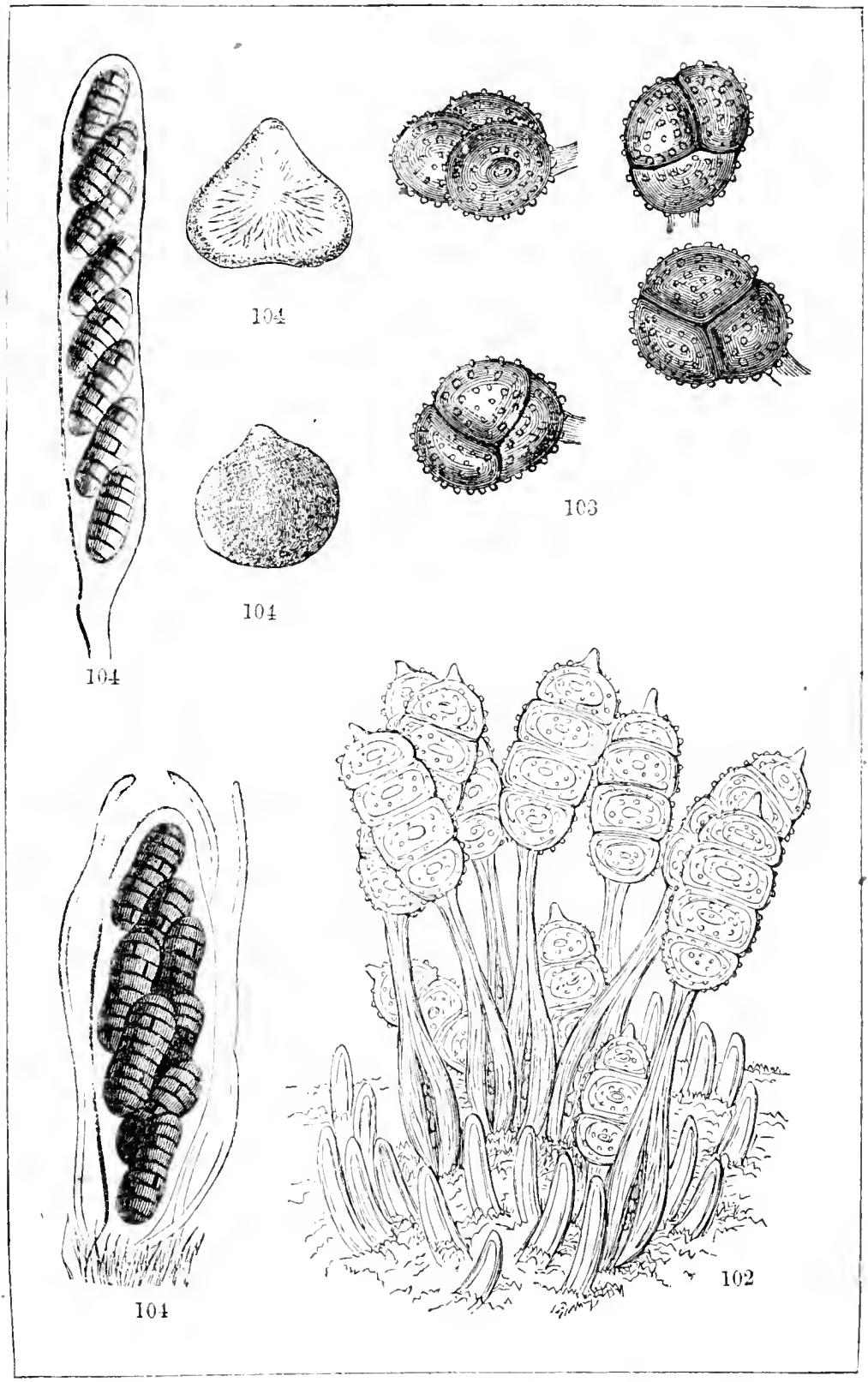
The collector is well prepared for a botanical expedition when he has furnished himself with a common gardener's trowel, a strong knife (if provided with a saw so much the better), and a tin vasculum, the latter larger or smaller according to the probable duration of his trip, the time of year, the plants likely to be met with, &c.*

If, on returning home, the flowers have closed their petals, as frequently happens, it is only necessary to set the roots in a basin of water, until the corollas have again opened, when the roots may be roughly dried, and the preservation of the plant proceeded with. Should they be wet from dew or rain, when gathered, they must be laid by until every trace of moisture has disappeared; other-

* A very useful instrument was brought under my notice, many years ago, by that eminent botanist, Philip Barker Webb. The accompanying figure exhibits its general form. The total length is 15 inches, of which the handle occupies rather more than one-third. The blade (which is triangular in shape each side of the triangle measuring seven-eighths of an inch where it joins the handle) is brought to an obtuse point. About midway between the two extremities, or, more correctly speaking, some $4\frac{1}{2}$ inches below the handle, it begins to make a gentle curve, the lower end being about one inch out of the true line. One of the angles forms the back of the curve. For convenience of carriage it should be fitted into a stout leather case. This instrument, which was Mr. Webb's invariable companion in his numerous Alpine excursions, is of great value for forcing plants from between the fissures of rocks, massive tree roots, &c.; in a word, from places where the broad surface of a trowel cannot be inserted, or would probably be broken, if it could be got in at all. It is also useful for extracting tap roots without injury from chalk or any other hard dry soil.

Fig. 114.

If made of good material, it will last a lifetime. My own has seen a good deal of rough service, but is practically in as good condition as when it was made twenty years ago.—Ed.



102. Aregma bulbosum. 103. Triphragmium ulmariæ.
104. Sphœria herbarum.

wise mould and mildew will speedily develop themselves, or at any rate the corollas will lose their bright tints, and the leaves become spotted and black.

As most of our readers must be aware, all these plants are prepared for the herbarium, by being laid between sheets of paper and placed under pressure. The choice of paper for this purpose is by no means a matter of indifference, as the beauty of the specimens and their ultimate preservation depend in a great measure on the speedy and thorough extraction of the fluids contained in their tissues.* Blotting paper is an excellent material; but the quantity required when the gatherings are on a large scale prevents it from being ordinarily employed. On the whole, common printing paper may be recommended with safety; and the cheapness and abundance of newspapers in the present day makes it easily attainable in large quantities.

Proof, however, should be made of its powers of absorption before being used; for some of the newspapers are prepared in such a manner as to prevent them from imbibing water freely.

One special point to be kept in view is, not to be sparing of the drying material, but to have so much at hand that frequent changes may be made. This is of the last importance, as a false economy is ruinous here.

In order to dry the sheets when they are removed from the press, they must be spread out in such a manner as to expose the largest possible surface to the air. But as this occupies more space than most botanists can spare, the following plan will be found of service: it is quite as effectual, and the eye is not offended with the sight of numberless papers lying in disorder about the floor of a

* An excellent paper in appearance (I have not yet had the opportunity of trying it), is manufactured expressly for botanical purposes by E. Newman, Devonshire Street, Bishopsgate, N.E.; and is also sold by Mr. J. Smith, 42, Rathbone Place, Oxford Street. —Ed.

room. Four or five sheets having been laid on one another, a thread is passed through them on the folded side, some two inches from the border; and then the two ends of the thread are tied together so as to leave a loop sufficiently large to admit of a longish rod or stick being passed through it. In this way packet after packet of damp paper is loosely fastened on the stick, and the latter is suspended horizontally in any convenient place, where there is a current of air—between the rafters of an out-house—across two chairs near a large fire—or, weather permitting, in the open air, where it will catch the rays of the sun. A few rods fitted up after this plan will allow of an immense number of sheets being dried at the same time. From the loose papers having both their sides acted on by the draught, they give up their moisture more quickly than if laid on the ground, and are not liable to be blown about by gusts of wind. The business of sewing the paper together is considerably lightened, if the end of a ball of thread is drawn, by means of a packing needle, through a great number of sheets at once, the thread being afterwards divided in lengths sufficient to bind up the packets as previously described. This saves the time, which would otherwise be wasted if the thread were cut into the required lengths before being passed through the packets.

As soon as the plants are freed from the moisture on their surface, and the paper has been distributed into convenient parcels of five or six sheets, the process of drying may be proceeded with by making alternate layers of packets and specimens until a height of some two feet has been reached. Next let the whole pile be placed between two smooth boards of the same size as the paper, and weighted with bricks, as previously recommended. Great attention must be paid to the degree of pressure laid on; if it be too severe the specimens will be squeezed out of all shape, whereas, if too light, the leaves, petals, and other tender parts will be shrivelled and wrinkled. It is a point on which experience and common sense must be brought to

bear, and they will be found safer guides than volumes of advice and description.

In arranging the specimen on the drying paper, the appearance it had when living is the first thing to be thought of; indeed, the main object in submitting it to a press at all, is that it may retain its form permanently. Before all things, therefore, care must be taken not to do violence to the plant, or force any of its members into positions which they could not possibly have held in their living state; otherwise an ill-shapen, distorted object, which can never be restored to anything like its original form, will be the inevitable result. For the same reason no leaf or twig must be removed for the mere sake of producing symmetry, or to indulge a false taste. The one grand point to be kept in view—I cannot impress it too strongly on the young student—to which everything else must be made to yield, is the preservation of the natural habit of the plant. If that is lost sight of, his herbarium may form a pretty object in the eyes of superficial observers, but it can never be a collection of plants by which science will be promoted, or a knowledge of botany advanced.

Of course there are times—and that not rarely—when it is actually necessary to curtail certain portions of a plant, in order that it may be prepared satisfactorily. Leaves, for instance, are constantly in the way, and must be removed to prevent them from concealing flower or fruit, or from being squeezed irregularly against the stem.

Whenever, then, amputation is unavoidable, let it be performed in such a manner that there may be no mistake about it—that, in a word, anyone may see at a glance that leaves, twigs, &c. really have been removed. To this end let the leaf, supposing a leaf to interfere with the due disposition of a flower, be cut off, not quite down at its junction with the stem, but a short distance up, so as to leave a good portion of the petiole adherent to the plant; and so of a twig, or a flower-head, or any other part, that must inevitably be sacrificed. But amputation had much

better not take place at all, if it be possible to do without it.

Should the specimen be too large to be contained within the compass of a sheet of paper, the stem must be cut half through at a convenient spot, and bent over, but at a certain angle, so that as little as possible of the upper layer shall press on the lower. Where the specimen is so long, that it is impossible to bend it so as to prevent its projecting beyond the paper, there is no help for it but to divide it into short lengths, care being taken to mark each part, so that their true connection may be seen at once. This can be easily managed by simply varying the shape of the cut: let the two corresponding sections be rounded, notched, truncated, &c., and no mistake can arise. But I repeat, let all amputation be avoided as long as possible.

As far as circumstances will permit, the different members of the specimen, I mean the leaves, stem, flowers, and so on, must not be permitted to lie directly on each other; for, if they do, they are almost certain to cling together and to become discoloured. Where it is impossible to avoid this, pieces of paper must be interposed; any kind of paper will suffice for the leaves, stalks, and less delicate parts, but for the petals only tissue, or thin note paper, should be used: indeed, the employment of the latter during the whole course of preparation, in addition to the regular drying material, tends greatly to preserve their colour.

Care must be taken, when arranging the order of the specimens one over the other, not to lay a thick woody plant next in succession to a thin slender specimen, as the latter will bear the impress of its stouter neighbour much to its detriment. Should it be found impossible to escape such an arrangement, the only remedy is to lay, not a single packet of paper as usual, but several packets between the two specimens—to heap them up, in fact, until the hand, when passed roughly over, fails to detect the protuberant stem beneath.

The young botanist, in the course of his investigations,

will meet with numerous plants, belonging principally to the family Crassulaceæ, such as Sedums and Sempervivums, which are so succulent and so tenacious of life, that they continue to grow after they have been laid between the sheets of drying paper. These require a special treatment of their own in order to destroy their vitality before any attempt is made to preserve them for the herbarium. To this end they are to be placed between two or three sheets of paper, the inflorescence alone projecting beyond it, and a hot iron is then passed over them. Two special precautions must be taken during the operation; one, that the flowers are not singed—the other, that the papers are changed more than once, as the plants being always of a succulent nature, a large amount of water is discharged by the heat.

There are some plants the surface of which is coated with a glutinous matter, which causes them to cling to the paper, especially when under pressure: indeed, some of the foreign Semperviva combine both these unpleasant contingencies, extraordinary vitality and extreme viscidity. To obviate the latter, the best plan is to sprinkle the specimen with the spores of Lycopodium clavatum—to be procured at most chemists under the name of 'Lycopodium.' The spores can be shaken off as soon as the plants are thoroughly dry.

Delicate water plants are often difficult to deal with, as their long trailing leaves and stems are apt to get hopelessly interwoven at the moment they are taken out of their native element, and it is an almost impossible task to separate them after they are dried. Such plants must be treated in the same way as was recommended in the case of the filamentous Algæ, viz. passing under them, while still in water, the paper, on which they are to lie.

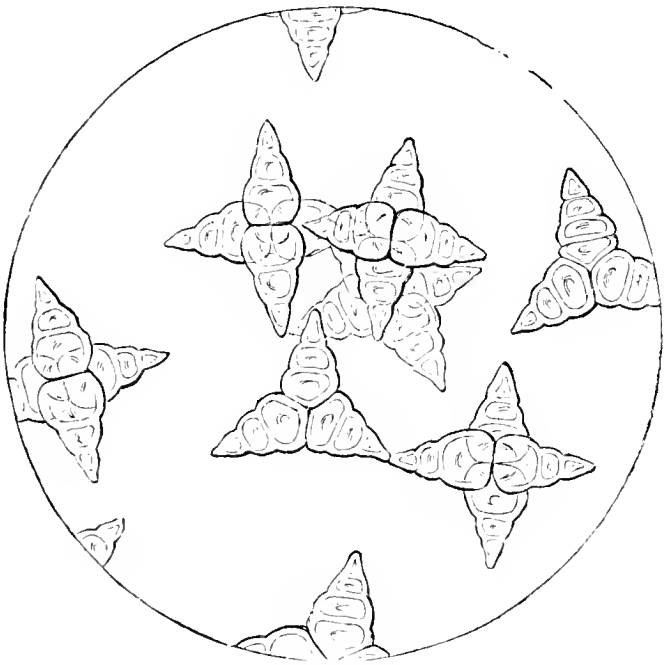
There are certain terrestrial plants, also of a fragile perishable nature, which must be laid at once between pieces of blotting-paper and not again disturbed until the whole process of preparation is concluded.

The packets of paper, between which the specimens are

first laid, absorb their moisture so rapidly as to require frequent renewing. The oftener this can be done during the first few days the better: indeed, the student should bear in mind, that whatever trouble he gives himself in this respect will be amply rewarded by the beauty and durability of his specimens; whereas a neglect of this precaution will as surely meet with its penalty in their discoloration and ultimate destruction by mildew and the ravages of insects.

The changing of the paper may be accomplished in the following manner:—Let the bundle of plants be laid on a table, and, on the operator's left hand, a pile of fresh dry packets. Now let the topmost layer be lifted off the plants, a blunt needle being brought into play where any part of the latter is found to adhere. On the specimen thus exposed, let a packet of dry paper be laid; then let both it and the packet on which the plant lies be slowly raised up, the same precautions being taken with regard to any adherent parts of the next underlying plant. The two packets, with the intermediate specimen, being now turned over, the dry one will of course be the lowest. The damp paper must next be taken off and replaced by a fresh packet. Proceeding in this manner a large pile may gradually be renewed by simply laying a dry packet on each plant successively, and turning it over on to the one which preceded it; and thus the whole work may be accomplished without injury or disturbance to the tenderest or most delicate specimen. Last of all, the pile is covered with a final packet, and again submitted to the press. I need scarcely add that, where the stoutness of a plant calls for it, several packets of paper should be interposed, as was directed to be done in the first instance.

During the first week the plants must be shifted daily, the succulent ones even oftener. After that, if they appear to be going on well, the changes may be made less frequently; at the same time the operator must be very careful not to remove the weights too quickly, or the consequences will be most disastrous.



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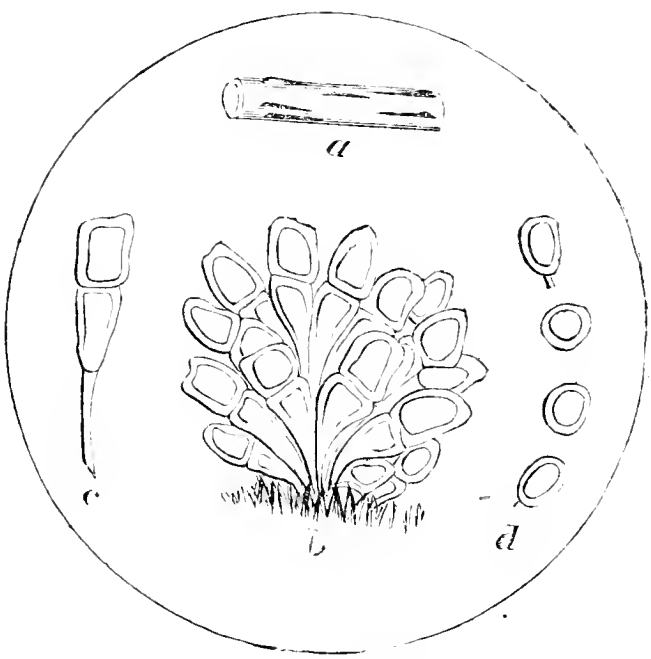


106

105. Asterosporium Hoffmanni.
106. Puccinia graminis. *a.* natural size; *b.* magnified; *c. d.* uredo form.

There is one point on which it is very difficult to give advice—I mean the ascertaining, with anything like accuracy, the degree of dryness to which the specimens have attained. Here each one must be left very much to his own sagacity, because, after the superficial moisture has been absorbed, and the plant has become more or less stiffened, the mere passing the hand over it will seldom betray the presence of damp. The best plan with which I am acquainted, is to lay the specimen against the cheek; if it imparts a sensation of coldness, it may be inferred that there is still a good deal of damp to be got rid of. At any rate, it is always better to 'err on the safe side' by leaving the pile of plants longer under the press than their actual condition may seem to warrant or to call for.

I will lay before the reader another method of preparation, which is recommended by many experienced botanists. It consists in laying each specimen between a sheet of very thin blotting-paper before placing it on the regular drying-paper. The specimen is to be arranged in the usual manner on the open sheet, the upper half of which is then carefully folded over, and a packet of drying-paper laid on, proceeding in the same way with each specimen. When it is requisite to change the packets, the damp one is removed, and the thin envelope to the plant is simply lifted up (without opening it, or in any way disturbing its contents) and laid upon a fresh packet of drying material.

It is true that many good botanists are opposed to this plan: they think that the moisture retained in the thin sheet at each renewal is likely to cause permanent injury, and that it is scarcely counterbalanced by the facility which it gives of lifting the specimen without disturbance. But in point of fact the blotting-paper retains a mere trifle of moisture, which it quickly imparts to the new packet, and, with ordinary care, very beautiful results may be obtained. I am acquainted with a person who prepares thousands of examples yearly for a society of naturalists; nothing can exceed the beauty or the durability of his pre-

parations, and yet every one of them is dried in the manner I have just been describing. The truth is, that every mode of preparation depends greatly upon the foresight, the patience, and the handiness of the operator; and impatient, unskilful workers will make a failure with even the best of means at their command.

An arrangement advocated by Auerswald has much to recommend it. I cannot speak of it from my own experience, but I feel bound to mention it for the benefit of those who make long botanical excursions, and collect large quantities of plants, as it is likely to save them both time and labour. In the ordinary method of drying, where the sheets are placed between two boards, the upper and lower sides not being exposed to a current of air, the moisture can escape only through the open edges of the paper. The consequence is, that a large quantity of paper is wanted, and a good deal of time is consumed in the preparation. Auerswald's object is to economise both these important requisites—time and material; and he accomplishes it in this manner:—Instead of two solid boards he provides himself with a couple of iron frames of a size to suit the paper; they should be light and thin, but at the same time strong enough to allow of being strapped tightly together without bending: wire netting is stretched across them, and on each of their longer sides two loops are fastened for the leather straps to pass through. In the middle of one of the shorter sides a ring is attached for the convenience of carrying the parcel, or in order to suspend it in the open air and sunshine.

Now, as the moisture contained in the plants can readily escape on every side, it stands to reason that the work is done much more quickly, and the traveller is saved both the time consumed in shifting his plants, and also the heavy load, which he must otherwise carry about with him. Doubtless many succulent plants will not come out so well under these circumstances as they would with the con-

veniences and appliances brought to bear on them in the botanist's own residence; but, on the other hand, it must be remembered that they would suffer greatly, perhaps as much, from being transported for a week or ten days in a vasculum, before they were pressed.

Two sets of frames with a proper supply of paper will be found sufficient; and, as soon as the plants are partially dried, which, with most of them, takes place within twenty-four hours, they may be transferred from the first to the second set. When the preparation is complete, they may be laid one upon the other for the convenience of carriage, without fear of any permanent injury being done to them.

To return to the more usual methods of preparation. Specimens collected on different occasions ought not, if possible, to be placed under pressure in the same pile; because the last and freshest are sure to impart some of their moisture to the others, which are already more or less dried, and are very likely to spoil them in consequence. If the piling them together is unavoidable, then they must be separated by thin boards, so as to prevent the damp from the plants more recently obtained being communicated to those which have already perhaps been shifted two or three times. For a like reason very succulent plants should not be put up with those of a less sappy nature; besides, the former require to be more frequently shifted than their drier neighbours; and to place them together would cause unnecessary disturbance to the latter.

[Through the kindness of a friend, I have lately been made acquainted with a process of drying, which, if we may judge from the very beautiful results obtained, leaves nothing to be desired. It consists in placing the specimen, soon after it is gathered, in a tall narrow vessel, and then pouring over it very gently a sufficient quantity of clean dry sand, to cover it entirely. In this state it is left undisturbed (unless, as sometimes happens, the drying material has to be renewed) until the moisture emanating from the

plant is absorbed by the sand. It is then removed with great care, and flattened in the usual manner, between sheets of paper. By this plan the petals retain their colour in a way that I have never seen equalled.—Ed.]

With regard to the physiological and anatomical investigation of the flowering plants, the limits of this little volume will not allow of my entering into it, nor would it lie within my province to do so.

[At the same time I offer no apology for concluding this chapter with the following useful suggestions from the late Dr. Lindley's excellent 'Descriptive Botany.'

'The student should select for examination as perfect a specimen as he can obtain, and should carefully study every part. . . . In doing this he must on no account guess, but be certain that he sees correctly, what is before him. This is not difficult in the case of roots, stems, leaves, and their parts; but the flower, from its general smallness and somewhat complicated structure, demands a little skill in dissection, which is only to be gained by experience.

'After its external structure has been determined, it is necessary to open the flower. Mere looking down into its tube or interior leads to nothing but error. The student should hold it in his left hand, and split it longitudinally by a rapid cut from below upwards. This lays bare the whole of the interior, shows the number and position of their parts, and their insertion, which is very important. If he attempts to divide a flower by cutting it from above downwards, he only crushes and disfigures his specimen. In the case of the ovary it is usually necessary to ascertain its placentation, which, if it is not seen in the first longitudinal section, can be best determined by making a transverse section. . . . In examining seeds of any kind, where dissection is required, cut into them perpendicularly, beginning at the hilum, and passing the knife through the axis: in this way the embryo and its relation to other parts usually becomes distinctly visible. Failing this, the observer must

have recourse to crushing or careful skinning and unrolling. . . . When parts are shrivelled or dried up, as is always the case in herbaria, they must be relaxed by immersion in boiling water.

'In all cases where dried flowers are to be dissected, the air should be driven out by boiling for a short time, before any attempt is made to separate their parts.'—Ed.]

CHAPTER XVI.

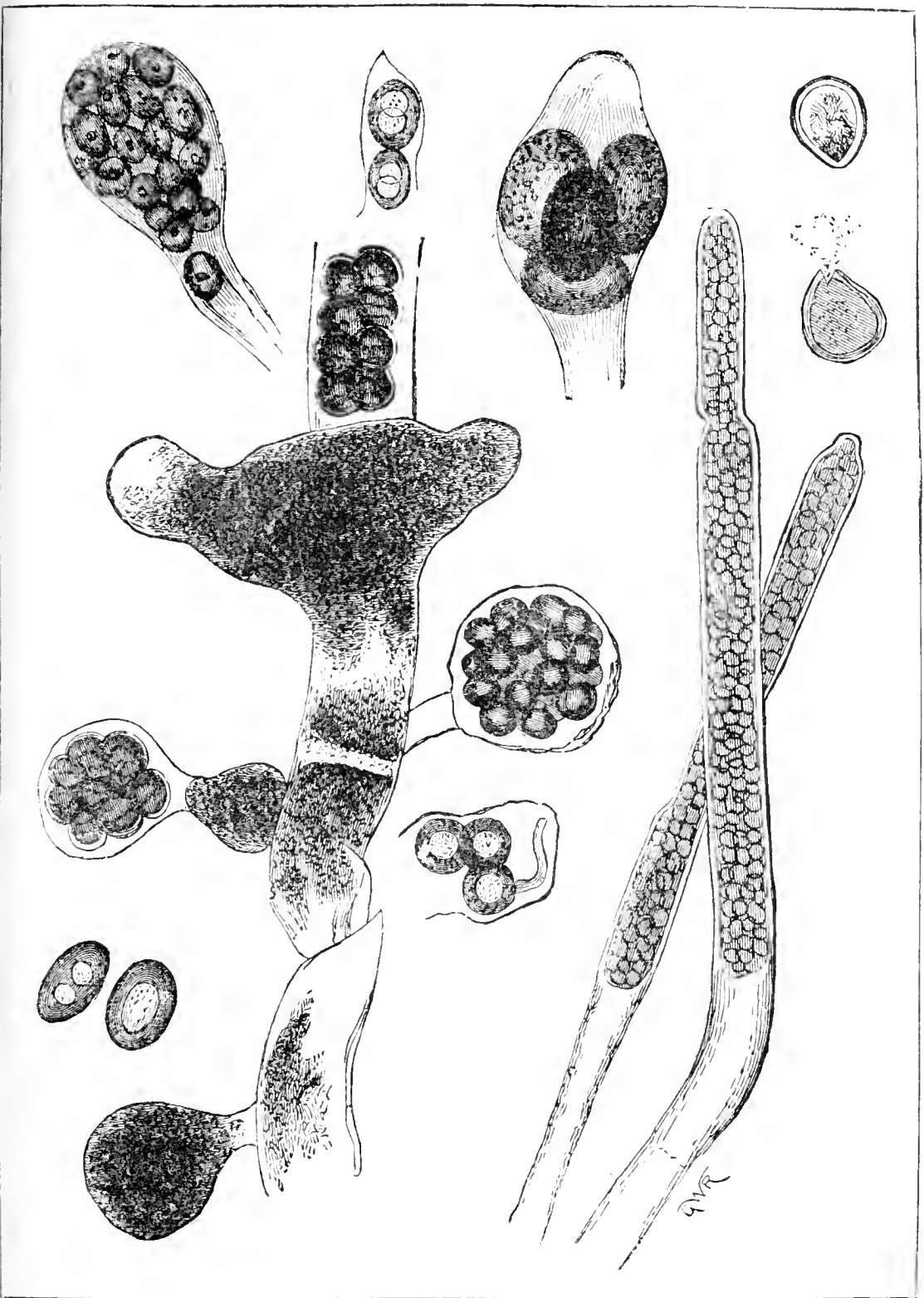
OF THE HERBARIUM.

THE OBJECT which the collector has in view (or at least should have in view) is, not the mere gathering together of a great number of different plants, but the acquisition of material, wherewith he hopes to enlarge the bounds of his own knowledge, and, so far as lies in his power, to advance the interests of science. For this purpose he arranges his examples in a certain definite order, grouping them together in the manner that seems most consonant to the system of nature; in one word, he forms an Herbarium.

Simple as this process may appear to the novice, it will not I trust, be superfluous to offer a few words on the subject, pointing out certain fixed principles, which should guide the student in the arrangement of an herbarium intended to be scientifically useful: to these shall be added some suggestions to aid him in its preservation. For the best arranged and most admirably got-up collection is certain to fall before the assaults of its numerous enemies, if not properly looked after.

As my readers are by this time well aware, the first step towards the preservation of a dried specimen is to place it between a sheet of paper; and this applies to plants of every known order with the exception of a few, which are either too large (like the Laminariæ), or which cling too tenaciously (as many Lichens do) to a stone or some other rough object, to be removed.

Provided that the specimens are laid upon clean white paper, the choice of the wrapper may be left very much to the fancy of the student; it should not be very thick, otherwise the fascicles will take up too much room; and



107. Achlya prolifera.

it should be uniform in size and appearance. The kind that I have always used is a stout light brown material, much employed in packing; it measures seventeen inches by twelve; the white paper on which the specimens lie, measures fifteen inches by nine. This is quite the largest size I would recommend; anything wider or longer than this becomes cumbersome and difficult to manipulate; in fact, a size smaller would probably be quite as efficient. In any case, whatever form or size is adopted, let not the student, from any motives of economy, employ too cheap a wrapper: above all, let him avoid the thin gray and blue sorts, so much used on the Continent, and frequently imported into England with foreign herbaria. (In Germany it is known as 'Fliesspapier.') The innumerable hollows arising from the inequalities of surface in cheap papers invite colonies of insects to take up their abode; while, from their rough uneven nature, it is impossible to eject the 'voracious crew' from their head-quarters, when once they have established themselves. Another objection to a too flimsy wrapper is its great flexibility, and the consequent injury likely to accrue to the enclosed specimen, every time it is handled.

We will now suppose the plants to be laid, each species by itself, on their half sheets of white paper, and these again slipped within the fold of their wrappers, the opening of the wrapper looking to the left hand. If the examples of any given species are numerous, representing varieties, abnormal forms, or growths from different localities, they must be laid on separate white sheets, but enclosed in a single wrapper. In all cases, however, the wrapper must be confined to one species, or section of a species, if, as is often the case, the latter is subdivided. This last suggestion must be carefully attended to; otherwise the arrangement of the herbarium will be constantly interfered with; besides, there is a great danger of the tickets being transposed from one species to another, whenever the wrapper is opened for

the purpose of examining its contents, which might cause indescribable confusion.

Dried specimens of the Phanerogamia and Ferns may be laid on their separate papers at once without any further manipulation, with the exception of the smaller and more fragile species, which should be previously fastened on to a piece of paper by means of adhesive slips, passed across the stem, &c. Mosses and Hepaticæ may be fixed to the paper by touching a portion of the tuft here and there with gum, not by smearing the whole under-surface, as beginners are apt to do.* Some, at least, of the Mosses should be preserved in paper bags, as the fragile organs of fructification, the calyptra and operculum particularly, are very apt to be rubbed off and lost, from their unavoidable collision with the surface of the wrapper, whenever it is moved. As regards the Lichens, which are generally attached to some rough surface, such as a piece of rock or wood, the student

* I must confess myself altogether opposed to fixing the specimens at all, except in rare instances, where in fact it is unavoidable, as with most of the Algæ. Of course something must be done to secure the safety of the smaller plants, or they will be constantly shaken out of their places, broken, and lost. I prefer to fold in pieces of paper the very minute examples—as, for instance, many of the Hymenophyllaceous Ferns, or the tiny Myosurus minimus—gumming the lower surface of the packet to the half sheet of white paper. In this way three or four may be placed on a single half-sheet, without any danger of their rubbing against each other. The author himself supplies us with an argument in favour of this mode of proceeding in the very next sentence to that which has given rise to this note. Less minute specimens—such as the delicate masses of the aquatic Ranunculaceæ—may be kept in their place by passing a tolerably broad band of paper, not too tightly, across the whole—the band being adhesive at the two extremities only. The specimen can then be slipped in and out of its guard with the greatest ease, when required for examination. My reason for recommending this plan is, that the smaller the plant and the more minute its structure, the more need is there to have it in one's power to examine it by transmitted, as well as by reflected, light; and how is the former to be accomplished, if the specimen is permanently glued to an opaque object?—Ed.

must, first of all, decide whether the preparation is sufficiently thin and flat to be laid between the sheets of the herbarium, or whether it must be kept in a separate cabinet, like a specimen of mineralogy.

A large number, those which have a crustaceous thallus, and others which are not attached to their support by their whole circumference, may be disposed of in the first mentioned way; care being taken that the stone or wood be made as thin as is compatible with the safe keeping of the epiphyte: to prevent any undue pressure between neighbours, they should be placed by the side of, not exactly over, each other. Certain, however, of the gymnocarpous section (like Calycium and Coniocybe), which are characterised by stalked apothecia, would be spoiled, if their safety was not better cared for. These should be deposited in chip or pasteboard boxes with covers, or they may be fastened on cardboard, with strips of wood, gummed on each side, of sufficient thickness to keep the specimen from being rubbed: a piece of cardboard laid on the wooden strips will still further ensure its integrity; it may then be laid between the pages of a wrapper, as usual.*

In very large collections coarse solid objects, such as stones, which have been encrusted by Lichens, should be put away in drawers and boxes, apart from the herbarium. At the same time, as their absence necessarily causes a gap in the systematic arrangement of the specimens, it is well to deposit in the place, which should have been occupied by the Lichen, an empty sheet of the wrapping paper with a label, which bears on its face the name of the missing species, and the number, with which it is ticketed in the drawer.

The same mode of proceeding may be adopted with

* All adhesive materials, as gum, &c., should be first poisoned by an infusion of corrosive sublimate; or a small quantity of some essential oil should be mixed with them. This prevents the growth of Fungi, and the attacks of insects.—Ed.

those Fungi and Algæ which cannot be preserved in the herbarium, on account of their size and roughness. Microscopic Fungi, on the other hand, growing on leaves, twigs, &c., should be fastened down by adhesive slips, [but in such a way as to allow of their being taken out and replaced, Ed.,] all superfluous wood having first been removed, so as to render the specimen as thin and flat as possible. Sections of the pileus, hymenium, &c., may be similarly treated, and put away in the herbarium.

Finally, as regards the Algæ, the original conditions of their preparation, as the reader will remember, necessitated the application of paper, before they were removed from the water; to this support they generally cling with the greatest tenacity, scarcely rising above the surface—indeed very often having all the appearance of a delicate painting.

The precautions requisite for the preservation of the Diatoms and Desmids have been already fully described, in the chapters devoted to those subjects.

Every plant should have a label attached to it, on which is inscribed its name and certain other notices, which should not be omitted.

These are—

1. The name of the family, genus, species, and variety, in the Latin language. The Latin tongue (interlarded with Greek) has been fixed upon, by common consent, as the medium of communication in the scientific world, or, at least, over the wide domains occupied by the kingdoms of botany and zoology. By this means uniformity of nomenclature and accuracy of description are to a large extent obtained: more so, at any rate, than when the titles are given in either of the living languages; for these are of merely local value, are without meaning to foreigners, and often incomprehensible beyond the narrow limits of a district.

2. The name of the author, that is, of the person who first gave the species the denomination, by which it has since been recognised. It is written in an abbreviated

form immediately after the second name of the plant: thus, 'Sonchus arvensis, *Linn.*' (for Linnæus), 'Lastrea cristata, *Pr.*' (Presl), 'Synedra acicularis, *W. Sm.*' (William Smith).

This addition of the author's name should never be omitted, because the same plant is often published under different names; and, as often, widely different plants are described under the same name. We have an instance in one of the examples given above: 'Synedra acicularis, *W. Sm.*,' is a diatomaceous species found in brackish water, to which the name of Synedra lævis has been given by Kützing, while, to make confusion worse confounded, this last author's Synedra acicularis is a fresh water species, which Smith calls 'Nitzschia acicularis;' so that it is not only not identical with the first-named Synedra acicularis, but actually is a separate genus! If then, in such a case as this, the student simply gave the name of the plant without that of the author, no one would know which Synedra acicularis was intended, that of Smith or of Kützing. Examples of this kind might be multiplied indefinitely.

To the name of the author should also be added, if possible, the title of the work in which the species was first described, with a reference to the volume, page, &c.; the whole to be enclosed in brackets. All the longer words to be abbreviated.

3. A list of the synonyms, or, at least, the more recent ones; that is to say, the names which have been given to the specimen by authors of repute, in addition to the one by which it is generally known and accepted. These it is usual to place between brackets, immediately under the established name, together with the work in which the synonym was first made known to the world.*

* So huge has the catalogue of synonyms become, that in many instances it would be simply impossible to recount them without overstepping the limits of any ordinary label! The common Cysto-

4. The locality where the plant was growing when it was gathered; in other words, the name of the mountain, marsh, town, village, &c., on or near which it flourished. Any information of this nature is of the greatest benefit to later botanists, especially in the case of rare kinds. [Great Britain is so restricted in extent, and so well hunted over by botanists, that it is sometimes actually necessary, if a new acquisition to our Flora is to retain its place, to conceal its locality from the eyes of those, who are botanists in name, but exterminators in fact. These, however, are exceptions; and on the Continent, with its vastly larger surface, and greater distances to travel over, it is of benefit instead of injury, to disclose the whereabouts of any given species.—Ed.] Thus Orthotrichum rogeri, *Br.*, has been gathered on the Jura Alps, but has never been rediscovered, because the description 'Jura Alps' was too vague and indefinite to be of any service to future collectors.

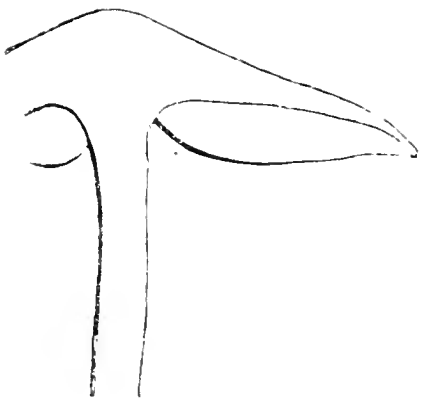
To the geographical or topographical position should be added a word or two, descriptive of the soil on which the individuals flourished, whether dry, swampy, woody, &c.

It is frequently also of service to indicate the geological formation underlying the locality;- the influence of the subsoil on the development and general character of the plant being often very striking.

5. The date on which the specimen was gathered. This, too, is of importance, as marking the season of flowering, fruiting, &c.

6. The name of the collector, and, if the example has passed through another hand, that of the person, from

pteris fragilis, *Bernh.*, enjoys at least twenty-seven different aliases. Of the still more common Pteris aquilina, *Linn.*, Sir William Hooker--having first enumerated seventeen or eighteen names—writes (Spec. Fil. ii. 197): 'Other synonyms might be added, if it were worth encumbering our pages with them. . . . Mr. Moore has twenty synonyms under the European Pt. aquilina, without taking into account Pt. esculenta, caudata, &c. of authors!'—Ed.



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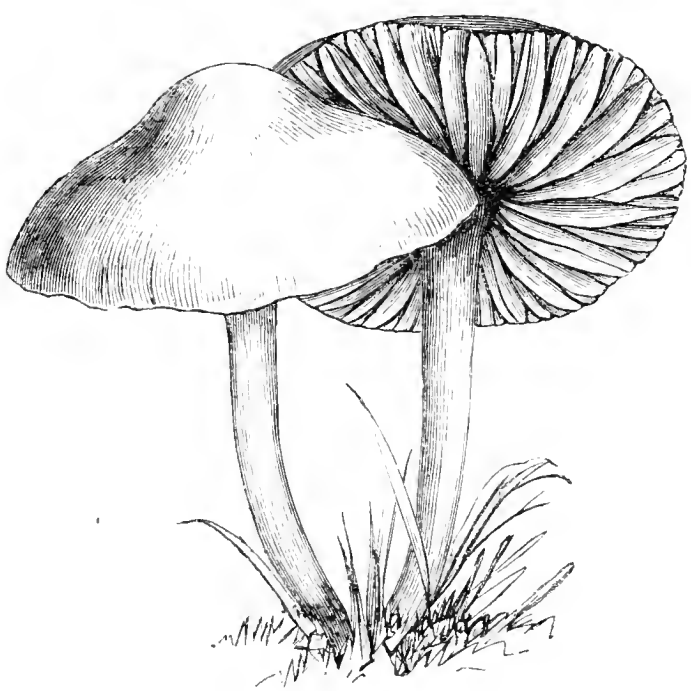


108

108. Marasmius oreades.

109. Marasmius oreades, section of.

whom it was received. These particulars are guarantees of the genuineness of the specimen; they also impart to it considerable authority, where the collector and communicator are known in the botanical world as accurate observers and safe guides. It is usual to write these in Latin and to abbreviate them thus: 'Leg.' (for legit, 'collected,') and 'Com.' (for communicavit, 'communicated'); or 'Ex Herb.' (for ex herbario, 'from so and so's herbarium').

Below is an example of a label, illustrating the various points to which I have called the reader's attention.

Diatomaceæ.

Nitzschia acicularis, *W. Sm.*

(Synops. Brit. Diatom. vol. i. p. 43, tab. xv. 123.)

(Synedra acicularis, *Ktz. Bacill.* p. 63, tab. iv., f. 3.

Ceratoneis acicularis, *Pritch. Infus.* p. 783.)

B. closterioides, *Grun.* tab. xii. f. 19.

Near Brünn in Moravia, in a ditch of clean, but stagnant, water.

Formation, Syenite.

Leg. J. N. July 15, 1863.

Com. (or ex Herb.) A. B.

Any observations, which the collector has the opportunity of noting down in regard to the life history of the individual plant, add greatly to the value of his collection; but I need scarcely add, that they must be perfectly trustworthy, and formed on his own experience.

There is no recognised form of label to recommend to the student; as long as he takes care that it is not too small, and that it is unencumbered with finical ornamentation, he can choose the size and the form that he fancies most for himself. If he wishes his herbarium to have a particularly neat appearance, he can have slips of paper cut, and printed at a small cost, something in this form:—

Herbarium (with his own name added).

Fam., &c.

Loc.
Form.
Leg. Date.
Com. (or ex. Herb.)

The labels had better be laid under the specimen, when the latter is not fastened down, as then they are not so easily lost at the opening of the wrapper; at the same time the name should be left exposed, so as to avoid disturbing the plant, each time the name is required. Where the specimen is fixed down or kept in a paper bag, the label may be attached by means of gum arabic.

To the young student it may appear the simplest plan to write the name, &c., at once on the paper on which the specimen lies, without the intervention of a label. But experience has proved that the latter plan is the most advantageous. In the first place, there is frequently no room on the half-sheet, a good-sized plant with its leaves and twigs occupying nearly the whole of its surface. Again, the plant may be wrongly named, for the beginner must naturally expect to make numerous mistakes in nomenclature. Now (supposing the name to be written on the paper itself), as soon as he discovers his error, either corrections must be made, giving the specimen an unsightly appearance, or else a new half-sheet must be introduced, an unnecessary waste; whereas, in the case of the label, he has only to remove the old one and substitute a new one in its place.

It is customary, when a specimen is received from another

botanist, to retain the original label, *i.e.* the one sent with it; if, however, the name employed by the giver differs from that in the system after which the student arranges his own herbarium, then let him add a second label with the necessary information.

It frequently happens with some of the Algæ, that the species gathered are irretrievably mingled together, so that it is hopeless attempting to separate them: this is more particularly the case with the Desmidiaceæ and Diatomaceæ. If the collector has sufficient material, he should proceed to make as many preparations as there are species in the gathering, introduce them into their proper places, and ticket them accordingly. For instance, we will suppose, that there have been taken at one gathering specimens of Gomphonema, Pinnularia, Meridion, Synedra, Fragilaria, and Closterium. Should he not be able to separate them satisfactorily, let him make six different preparations, each containing examples of the several genera. Next let him inscribe one label with the Gomphonema species, another with the Pinnularia, &c., and arrange them in his herbarium as though the species denoted by the ticket were the only one present in that preparation.

When, however, the gathering is too small in quantity to allow of dividing it in this manner, he must make a single preparation, but place labels, corresponding to the number of species in the preparation, in their respective wrappers. Thus, taking the last-named illustration, the preparation will occupy the wrapper apportioned (we will say) to Gomphonema; the others, Pinnularia, Synedra, &c., will be represented in their wrappers by tickets, labelled with their names, and referring the reader to the Gomphonema preparation.

I strongly recommend the student not to be satisfied with solitary examples of plants from a single habitat. The delicate shadings and variations, due to differences of situation, soil, and climate, cannot be rightly appreciated, until the observer has before him an abundant supply of

material from different localities, embracing widely-separated areas.

The more numerous the localities represented in an herbarium are, the more valuable is it in the eyes of the man of science. For the same reason he should bring together, in the case of the Phanerogamia, not only flowers, but ripe fruit, both with and without the capsule, or, if the plants are diœcious, examples of both the sexes; in the case of the Cryptogamia, sterile as well as fertile forms from numerous localities, since, in many cases (as for instance among the Mosses) peculiarities of situation, hindering or promoting the fertility of a plant, influence its habit and character in no slight degree. In a word, in each order of plants, the collector should endeavour to obtain the successive stages of development, if he intends to study them thoroughly, and to give a scientific value to his collection.

That he may study the specimens with ease, his herbarium should be so arranged, that he may be able to lay his hand at any moment, and without loss of time, on the example he wishes for; and also be able to take it out and replace it without injury to the collection.

For this, I recommend the following plan. The wrappers being laid on a table with their openings looking to the left, the whole of the species belonging to a single genus (or a section of them, if the genus is very large) is to be lifted off the pile, and enclosed in a separate wrapper, the opening of which looks to the right. This arrangement tends greatly to convenience in handling the specimens, as the operator can remove each genus, (or, it may be, portion of a genus,) with the greatest ease, and, when properly labelled, any desired genus can be got at without disturbing the other packets.

The genera included under an order should next be isolated. As a rule, this involves a pile of specimens much too bulky to be comprehended within the limits of a single wrapper. The better plan, therefore, is to lay the pile between two sheets of stout pasteboard of corresponding size,

(just as they were before laid between two boards during the process of drying), and either tie them round with thick string, or buckle them together with a strap of a woven material. The beginner is often tempted to lay out his money on nicely got-up portfolios, in which to enclose the orders; but, if he will take my advice, he will save his money, and be content with the pasteboard covers, though their appearance is certainly less elegant. My own experience is decidedly in favour of the latter, because, first of all, much time is consumed in the tying and untying of the numerous ribbons, with which a portfolio is furnished; and, secondly, because the pressure of a tight string or strap (especially the latter, on account of its breadth) is much more equal. Besides, the ribbons are apt to break off with constant use, and they cannot be replaced without giving an untidy appearance to the portfolio; whereas a string, or strap, can be renewed at will.

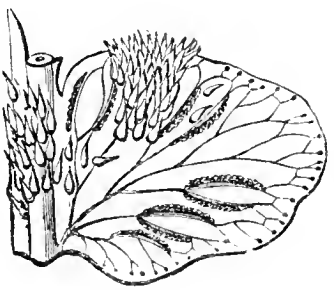
Should the roots (as sometimes happens) interfere, from their thickness, with the proper disposition of the packets, raising them up at one end, and forcing the whole pile out of the level, it is easy to turn a certain number of the packets round, thus doing away with the unevenness of the bundle, and giving it the desired flat surface. Next for the best system of labelling. First gum a ticket just above the lower border (and equidistant from the two corners) of the pasteboard cover, with the name of the order upon it. Then, on the lower left-hand corner of the 'Genus' wrapper, let a ticket be gummed, bearing the name of the genus; similarly, on the lower right-hand corner of the 'Species' wrapper, gum a ticket, bearing the name of the species, preceded by the initial of the genus: thus 'R. Köhleri' marks the species 'Köhleri,' of the genus 'Rubus.' If the names are written in bold legible characters, they cannot fail to catch the eye of the observer immediately on his turning over the wrappers.

But how is the student to grope his way through the mass of paper, accumulated in his herbarium, in order to

lay his hand on any wished-for specimen? This is easily effected by the simple process of numbering the tickets outside the wrappers, one set of numbers for the genera, and another for the species in each genus, the orders being distinguished by Roman figures. Whatever systematic work the student has taken as his guide in the arrangement of his herbarium may be made the groundwork of his numbering. Should the work in question not be numbered, the student will have no difficulty in going himself through the volume, first marking the genera from beginning to end with consecutive numbers, and then the species, in these confining the consecutive numbers to a single genus. All that is requisite now is to look into the index of the book for the genus to which the desired specimen belongs, and to ascertain its number. Then, by keeping his eye on the external labels of the herbarium, the student can find the specimen without being compelled to open any but the right packet, and also with the least expenditure of time. A specimen can be replaced in the same simple manner. Of course the descriptive tickets accompanying the examples are also numbered; and the search is much facilitated, if a list of the genera contained in each order, or at least a list of their reference numbers, is slipped under the string or strap enclosing the fascicle.

When the herbarium has grown to a large size, so that individual packets are less frequently consulted, it is well to wrap the separate fascicles in paper, or, better still, in linen, bringing the ends well round, so as to overlap the centre, and tying them together by two strings fastened to the opposite corners of the covering material. Each string is carried right round the bundle, and looped in again, where its other end is attached to the linen cover. If paper is employed, the pasteboard covers must be placed over and under it, to keep it in place. In either case the list of enclosed genera may be slipped under the outside fastening.

111



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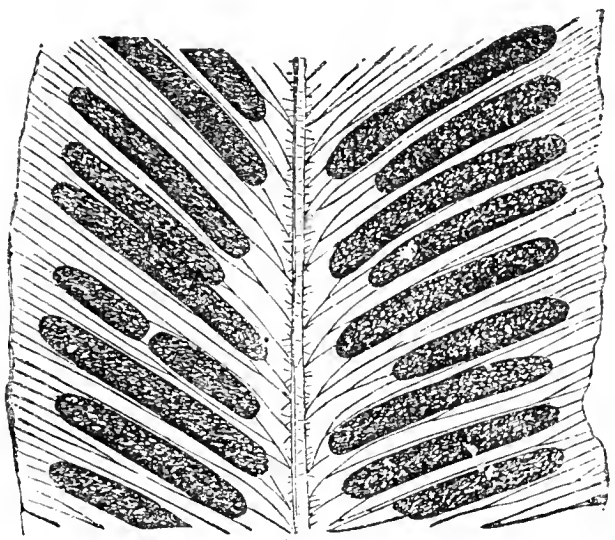


110

110. Scolopendrium vulgare, portion of mature frond.
111. Ceterach officinarum; *a*. portion of frond enlarged.

Although by this arrangement the difficulty of getting at the specimens is undoubtedly increased, still the advantages are great, where (as I observed before) the fascicles are not in constant requisition; it saves the specimens from dust, it keeps the wrappers in good order, and it helps to ward off the ravages of insects.

I referred just now to the need of selecting some systematic work as a guide in the arrangement of the herbarium. This is easily done as regards the flowering plants and the higher Cryptogamia; there are works enough published to satisfy the taste of every collector, whatever his views may be, whether Linnæan, Jussiæan, Candollean or Lindleyan. But this, I regret to say, is far from being the case with the lower Cryptogamia, the Lichens, Fungi, and Algæ. Independently of the fact, that the systems hitherto arrived at are far from perfect, there is the additional circumstance, that science in its onward strides is ever bringing new species to light, or compelling the re-arrangement of those with which we are already acquainted. Consequently, we must either find room in our catalogue for species of whose existence we had no conception a short time before; or, on the other hand, we must be prepared, in consequence of a deeper insight having been gained into their structure and habits, to separate species, hitherto closely combined, and not unfrequently to place them in distinct genera.

To meet these difficulties a certain elasticity must be allowed to the catalogue, so as to permit of the names of species being introduced or removed without disturbing its general arrangement. For this purpose quarter-sheets of foolscap paper are prepared; one, two, or three for each genus, according to its size. The generic name, with its reference number, being placed at the head of the paper, the species are added in due order beneath, a considerable space being left between each name to admit of others being introduced. In this way new species can be inserted in their proper places, without having recourse to endless interpolations, which disfigure the page and confuse the reader.

Should the genus be so extensive, as to necessitate the division of the species into sections, it may be labelled and catalogued after the following fashion. We will suppose that the Diatomaceous genus Nitzschia is the 138th in the system adopted by the student, and that he possesses the species named below.

138. Nitzschia, *Hass.*

a. Frustules arcuate.
1. N. amphioxys, *W. Sm.*

b. Frustules constricted in the centre.
1. N. plana, *W. Sm.*
2. N. constricta, *Pritch.*
3. N. parvula, *W. Sm.*
4. N. latestriata, *Bréb.*

c. Frustules sigmoid.
1. N. sigmoidea, *W. Sm.*
2. N. curvula, *W. Sm.*

d. Frustules straight, linear, or lanceolate.
1. N. tenuis, *W. Sm.*
2. N. communis, *Rab.*
3. N. hyalina, *Greg.*

It will be observed, that the sections are marked by a letter of the alphabet, and that each commences with number 'one.' Care must be taken to leave sufficient space between each section to allow of the insertion of fresh names.

The herbarium is best preserved on the shelves of a closet provided with well-fitting doors to exclude the dust, and kept in a room in which a fire can be lit during the winter, and in exceptionably damp weather.

It is of no use, however, to take pains in preparing specimens, labelling them correctly, and providing them with shelves and drawers, unless the greatest care be taken for their preservation afterwards.

If the plants are liable to injury from damp or rough usage, still more so are they from not being touched at all. Neglect is worse than careless handling, or indeed than any

other of the numerous ills to which a 'Hortus Siccus' is exposed; because it is mainly due to neglect, to leaving the specimens to take care of themselves, that insects are encouraged in their depredations. The student may have an intense affection for his botanical treasures; he may handle them tenderly, when extracting some much-prized example; he may see that the room is duly warmed to prevent the admission of damp with its accompanying swarm of minute Fungi; but all his labour and love will be thrown away, if he be not constantly on the watch, turning over the sheets, and examining his favourites individually, scrutinising their condition, and looking with an almost microscopic eye for the first traces of the enemy. 'Principiis obsta' should be the motto inscribed over the portals of his cabinet. He must strive to prevent the fiend from entering his paradise at all; for if once he and his progeny gain a footing there, it will cost him many a weary hour's hard work to eradicate them.

As a means to this end, no plant, whether dried by himself, or communicated from some other source, should be introduced into the herbarium without first undergoing a strict investigation. Indeed, if a number of specimens are received in bad condition, it is always as well to 'sulphur' them, according to the plan given below, to prevent the possible infection of the whole cabinet. A world of future trouble and vexation will be saved, by taking care, in the first instance, that no ova or larvæ are concealed among the leaves or in the flower-heads.

Another necessary precaution is to 'poison' the specimens before laying them by. Frequent experiments have been made in this direction, with the view of discovering some means of warding off the attacks of the insect world, or at least of rendering them harmless. Not one of the numerous methods, however, can be pronounced absolutely certain in its operation. Many of the lower forms of plants, the Algæ, the Lichens, and the Mosses are, comparatively speaking, exempt from their ravages; but they seem

to revel in the destruction of the Ferns, the flowering plants, and the Fungi, especially the two last named. Strange to say, certain orders of the Phanerogamia are more liable than others to the visits of these 'pests of the herbarium.' I may mention the Willows, the Umbelliferæ, and the Composite plants, as among their favourite haunts. The Compositæ especially are greedily attacked by Anobium, Dermestes, &c., possibly because the large flower-heads, with which many of the species are furnished, afford them such admirable hiding-places. These, then, must be thoroughly impregnated with some poisonous substance, before they are finally deposited in the cabinet.

The best preservative medium with which I am acquainted, is a solution of corrosive sublimate in alcohol. To apply it, the specimen should be laid on a smooth surface of glass or tin, and well painted with the mixture, by means of a broad soft hair pencil. As the alcohol evaporates, a deposit of sublimate is left behind. In the case of very delicate plants or flowers, which are endangered by the touch of even a soft hair pencil, it is better to apply the solution through a glass syringe, thoroughly sprinkling every part. The specimen may be replaced in its wrapper as soon as it is dry, which takes place very speedily on account of the volatile properties of the spirits of wine. This poisoning process, be it understood, is by no means permanent: it is of service for a time, but only for a time, and must be renewed at stated intervals. My own experience leads me to suggest, that the herbarium should be carefully inspected twice a year, in the spring and autumn, and a coating of poison laid on to every plant, or, at any rate, on those which are most liable to the attacks of insects.

Camphor, oil of turpentine, and other strong-smelling substances, have been recommended from time to time, but I confess I have but little faith in them as preservatives. Indeed I have generally found, that they are far more

disagreeable to the botanist in his study, than to the insects in his herbarium !

Should it be found, that the larvæ, in spite of all precautions, have established themselves in any part of the herbarium, the infected packets must be at once removed, and submitted to the fumes of sulphur. For this purpose let a box be provided—if made of iron or lined with tin, so much the better—large enough to hold two or three of the packets. An air-tight lid being requisite, let a shallow groove or channel be run round the upper edge of the box to receive the lid when closed ; the groove itself is to be filled with water when the box is in use, thus rendering it air-tight. It is necessary to retain the fumes of the sulphur within the box, not only on account of their evil odour, but because they are apt to produce unpleasant, and even injurious, symptoms in the operator, if imbibed to too great an extent. For the same reason, the work should be carried on in an outhouse or in the open air, not in an inhabited room. A movable framework of iron fits loosely into the box, consisting of netting, or of a few cross bars sufficiently strong to support the packets, and resting on legs three or four inches high.

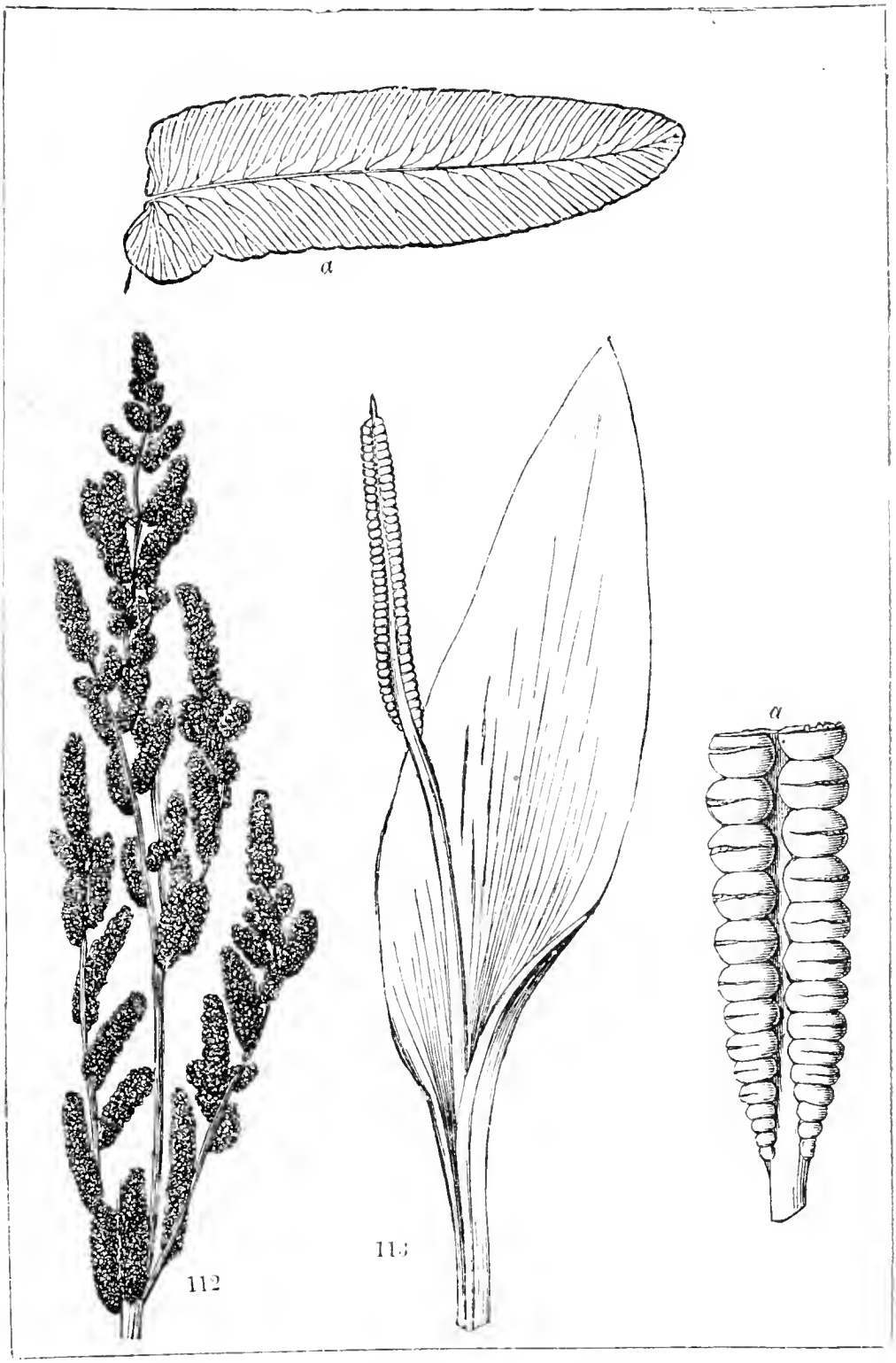
Now let a shallow pan of burning sulphur be laid on the bottom of the box ; the framework with its packets placed over it ; the lid shut down ; and the whole left undisturbed for about forty-eight hours ; and it will be found that at the end of that time not a single insect survives. I have had occasion to try this plan repeatedly, and never knew it to fail. [Another method, of which I can speak with approval, consists in placing the packets in an oven, and leaving them to bake for some hours. No form of animal life—at least of animals destructive to plants—can stand against the continued heat : it is especially useful in very damp climates. Care must be taken that the oven is not too hot, or the specimens will be rendered over-dry and brittle.—Ed.] The best season for making these experi-

ments is towards the end of summer, or even as late as October.

[HAVING now clothed in an English dress the results of Herr Nave's large experience in collecting, preparing, and preserving plants, I leave this little work in the hands of the reader, with the confident hope that he will pardon its defects for the sake of its object. That object will have been fully accomplished, if it be the means of awakening in the Botanical Student a desire to become more closely acquainted with the loveliest of all the Creator's works, or in smoothing some of the difficulties, which must inevitably surround the path of the tyro.—ED.]

'Thy desire, which tends to know
The works of God, thereby to glorify
The great Workmaster, leads to no excess
That reaches blame, but rather merits praise,
The more it seems excess . . . .
For wonderful indeed are all His works,
Pleasant to know, and worthiest to be all
Had in remembrance always with delight.'

MILTON.



112. Osmunda regalis. *a*. Pinnule of barren frond.
113. Ophioglossum vulgatum. *a*. fertile spike enlarged.

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