
II. PHYSICS and POLITICS; or, Thoughts on the Application of the Principles of 'Natural Selection' and 'Inheritance' to Political Society. By Walter Bagehot. Eighth Edition.


V. The STUDY of SOCIOLOGY. By Herbert Spencer. Fifteenth Edition.


VIII. RESPONSIBILITY in MENTAL DISEASE. By Henry Maudsley, M.D. Fourth Edition.

IX. The NEW CHEMISTRY. By Professor J. P. Cooke, of the Harvard University. With 31 Illustrations. Ninth Edition.

X. The SCIENCE of LAW. By Professor Sheldon Amos. Seventh Edition.


XII. The DOCTRINE of DESCENT and DARWINISM. By Professor Oscar Schmidt (Strasburg University). With 26 Illustrations. Seventh Edition.

XIII. The HISTORY of the CONFLICT between RELIGION and SCIENCE. By J. W. Draper, M.D., LL.D. Twenty-first Edition.


XVI. The LIFE and GROWTH of LANGUAGE. By William Dwight Whitney. Sixth Edition.


XVIII. The NATURE of LIGHT, with a General Account of PHYSICAL OPTICS. By Dr. Eugene Lommel. With 188 Illustrations and a Table of Spectra in Chromo-lithography. Fifth Edition.


XXI. The FIVE SENSES of MAN. By Professor Bernstein. With 91 Illustrations. Fifth Edition.

XXII. The THEORY of SOUND in its RELATION to MUSIC. By Professor Pietro Blaserna. With numerous Illustrations. Fourth Edition.

XXIII. STUDIES in SPECTRUM ANALYSIS. By J. Norman Lockyer, F.R.S. With Six Photographic Illustrations of Spectra, and numerous Engravings on Wood. Fourth Edition. 6s. 6d.


XXV. EDUCATION as a SCIENCE. By Alexander Bain, LL.D. Seventh Edition.

XXVI. The HUMAN SPECIES. By Professor A. de Quatrefages, Membre de l’Institut. Fifth Edition.


XXX. The ATOMIC THEORY. By Professor A. Wurtz. Translated by E. Cleminshaw, F.C.S. Fifth Edition.


London: KEGAN PAUL, TRENCH, TRÜBNER, & CO., LTD.


LIV. THE MAMMALIA IN THEIR RELATION TO PRIMEVAL TIMES. By Oscar Schmidt. With 51 Woodcuts.

LV. COMPARATIVE LITERATURE. By H. Macaulay Posnett, LL.D.


LVIII. GEOGRAPHICAL and GEOLOGICAL DISTRIBUTION of ANIMALS. By Prof. A. HILPRIN.


LXI. MANUAL OF BRITISH DISCOMYCETES, with descriptions of all the Species of Fungi hitherto found in Britain included in the Family, and Illustrations of the Genera. By William Phillips, F.L.S.


LXIII. The GEOLOGICAL HISTORY of PLANTS. By Sir J. William Dawson. With 80 Illustrations.

LXIV. THE ORIGIN OF FLORAL STRUCTURES THROUGH INSECT AND OTHER AGENCIES. By Prof. G. Henslow.


LXVI. THE PRIMITIVE FAMILY IN ITS ORIGIN AND DEVELOPMENT. By C. N. Starcke.

LXVII. PHYSIOLOGY of BODILY EXERCISE. By Fernand Lagrange, M.D.

LXVIII. The COLOURS of ANIMALS: their Meaning and Use, especially considered in the case of Insects. By E. B. Poulton, F.R.S. With Chromolithographic Frontispiece and upwards of 60 Figures in Text.

LXIX. INTRODUCTION TO FRESH-WATER ALGAE. With an Enumeration of all the British Species. By M. C. Cooke, LL.D. With 13 Plates Illustrating all the Genera.

LXX. SOCIALISM: NEW AND OLD. By William Graham, M.A., Professor of Political Economy and Jurisprudence, Queen's College, Belfast.
The

International Scientific Series.

Vol. LXIX.
INTRODUCTION
TO
FRESH-WATER ALGÆ
WITH AN
ENUMERATION OF ALL THE
BRITISH SPECIES

BY
M. C. COOKE, M.A., LL.D., A.L.S.
AUTHOR OF
"FUNGI, ITS NATURE, USES, ETC.," "BRITISH FRESH-WATER ALGÆ," ETC.

WITH THIRTEEN PLATES
ILLUSTRATING ALL THE GENERA

LONDON
KEGAN PAUL, TRENCH, TRÜBNER & CO., LtD.
1890
The rights of translation and of reproduction are reserved.
No apology is needed for the production of this volume, and hence there is little necessity for a preface. One justification may be found in the fact that the whole edition of my larger and copiously illustrated work on the same subject was soon exhausted, and could not be reproduced. Another justification will be the form and price of this book; for, with all the "manuals," and "handbooks," in the various departments of Natural History, there has never, until now, been any attempt to publish a cheap "handbook" of the British Fresh-Water Algæ. In these days of microscopical research the number of persons interested in this subject must be considerable, and a still larger number would have been attracted towards it, but for the almost prohibitive price of the books absolutely essential to the study. With the removal of this disadvantage it is to be hoped that
PREFACE.

the ranks of the students will be largely augmented. To have included the Desmids, and Fresh-Water Diatoms, would have prevented the realization of a cheap and popular handbook, whilst their absence will not interfere with the practical utility of this volume which is now commended to the care of the student and lover of nature.

M. C. COOKE.

Upper Holloway,
1890.
## CONTENTS.

<table>
<thead>
<tr>
<th>CHAPTER</th>
<th>PAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Introduction</td>
<td>1</td>
</tr>
<tr>
<td>II. Collection and Preservation</td>
<td>15</td>
</tr>
<tr>
<td>III. Cell-Increase</td>
<td>28</td>
</tr>
<tr>
<td>IV. Polymorphism</td>
<td>36</td>
</tr>
<tr>
<td>V. Asexual Reproduction</td>
<td>51</td>
</tr>
<tr>
<td>VI. Sexual Reproduction</td>
<td>66</td>
</tr>
<tr>
<td>VII. Conjugation</td>
<td>92</td>
</tr>
<tr>
<td>VIII. Pairing of Zoospores</td>
<td>105</td>
</tr>
<tr>
<td>IX. Alternation of Generations</td>
<td>113</td>
</tr>
<tr>
<td>X. Spore Germination</td>
<td>131</td>
</tr>
<tr>
<td>XI. Spontaneous Movements</td>
<td>142</td>
</tr>
<tr>
<td>XII. Notable Phenomena</td>
<td>159</td>
</tr>
<tr>
<td>XIII. The Dual Hypothesis</td>
<td>177</td>
</tr>
<tr>
<td>XIV. Classification</td>
<td>184</td>
</tr>
</tbody>
</table>

Arrangement of the British Species of Fresh-Water Algae | 191 |
Addenda                                              | 323 |
Glossary                                              | 327 |
Explanation of Figures                                  | 333 |
INTRODUCTION

TO

FRESH-WATER ALGÆ.

CHAPTER I.

INTRODUCTION.

The uninstructed observer practically encounters no difficulty in distinguishing the lower Cryptogamia from the higher Cryptogamia, and both of these from flowering plants. In other words, the unscientific person will readily recognize the differences between a Fern and a Seaweed, or between a Moss and a Fungus, without having recourse to an elaborate scientific diagnosis of character. General characters, which shall be unimpeachable, are exceedingly difficult to construct, and none yet attempted, even for the primary divisions of the lower Cryptogamia, are by any means perfect. With the progress of knowledge the difficulty increases, for the links multiply which unite one series of forms with another, so that logical demarcation seems almost impossible. In the majority
of instances, and to the ordinary observer, there seems to be no great difficulty in distinguishing a Lichen from a Fungus or an Alga, and yet instances may occur in which it is so perplexing that some authors have hoped to surmount the difficulty by constituting an intermediate group of Fungo-Lichens, because they are supposed to partake of the character of both. It may be that the similarity, in external appearance, in some species of Cladonia amongst Lichens to Clavaria in Fungi, will at first produce hesitation, but this is soon dispelled. It is not so easy, however, upon a casual inspection, to distinguish a Nostoc, which is included amongst Algæ, from a Tremella, which is a Fungus, or a Collema, which is a Lichen. From part of this difficulty some writers have sought to deliver us by maintaining that a Nostoc becomes eventually developed into a Collema, and therefore the Nostoc is not an Alga, and the Collema not a Lichen, but a combination of both. Whether this view be accepted or not, it demonstrates that there are difficulties in the way of generalizations.

Thallogen, or Thallophyte, are names which have been applied to the lower Cryptogamia, as indicating that they produce an expansion called a thallus, instead of leaves; but unfortunately the whole plant sometimes consists of a single cell, without any kind of thallus, unless the cell be accepted as a thallus in itself. Name or no name, this name or any other, is of little importance; the entire class or group may be
again divided into two component sub-groups, one of which represents the Algae, and the other the Fungi and Lichens. Let us accept, therefore, as sufficient for our purpose, the following definitions of the two sub-groups:

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

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

This latter sub-group being also subdivided into—

a. Fungi. Deriving nutriment, by means of a mycelium, from the matrix, never producing from their component threads green bodies resembling chlorophyll (gonidia).

b. Lichens. Deriving, for the most part, nutriment from the surrounding media, producing from the component threads of their thallus abundant gonidia.

We need not stay to inquire what objections may be urged against these distinctions, inasmuch as we are only concerned in distinguishing Algae from Fungi and Lichens, for which the above will be sufficient. All authors have felt dissatisfied with paper definitions, and yet, with all their imperfections, are compelled to resort to them. Nearly fifty years ago the
late Professor W. H. Harvey remarked, "Whoever has paid the slightest attention to the classification of natural objects, whether plants or animals, must be aware that, if we desire to follow natural principles in forming our groups—that is, to bring together such species as resemble each other in habit, properties, and structure—it is a vain task to attempt to define, with absolute strictness, the classes into which we are forced to combine them. At least, no effort to effect this desirable object has yet been successful. Natural groups are so interwoven into each other, and often exhibit such an exaltation and degradation of characters within the limits of an order or a genus, that the distinctive marks, as they approach each other, gradually disappear, and two tribes, which in the more highly developed species scarcely resemble each other, are found in the lower to be either undistinguishable, or with difficulty distinguished. If it be difficult to define groups among highly organized plants, it can be no matter of wonder that when we come to the Cryptogamia, whose structure is so much more simple and uniform, and whose forms are still more sportive, the difficulties become vastly increased. But it fortunately happens that these difficulties are much more formidable on paper than in the field. Thus, while the systematizer, in his study, may consume the midnight oil, till his aching brains are weary with the fruitless task, in attempting to express in words a character which shall include
every species of the class *Algæ*, and at the same time exclude every denizen of the allied groups, *Fungi* and *Lichens*; the student, roaming through the fields or along the seashore, finds no difficulty whatever in recognizing a *Seaweed*, as distinct from a *Mushroom* or a *Lichen.*

*Algæ* constitute the principal vegetation of the waters, especially of the sea, but largely of fresh water, very few of them being found to inhabit stations which are not submerged, or exposed to constant dripping; in all situations, great dampness is an essential of their existence. The lowest form of development consists of a single cell; the highest, of a kind of stem, with fronds, resembling leaves, many feet in length, and a basal expansion, or fibrils, which fulfil the functions of a root. Between these two extremes lie an endless variety of forms, and even the same species is subject to great variation.

Although *Algæ* flourish in salt water and in fresh, it by no means follows that the same species or genus is found under both conditions. Indeed, the contrary is the prevailing rule, to such an extent that the Fresh-Water *Algæ* may be studied independently of Marine *Algæ*. Very few Marine *Algæ* are to be found in fresh water, and these chiefly at the mouths of tidal rivers, and of but few species, whilst intrinsically *fresh*-water species cannot exist in salt water. It may appear to some to be a singularly artificial arrangement to treat

separately of Fresh-Water Algæ, making the separation to depend upon the medium in which they grow, but it will be discovered, upon better acquaintance, that, artificial as the arrangement may be, the fresh-water species and genera are sufficiently distinct to justify such a scientific heresy. It is no new thing to treat of the Fresh-Water Algæ, as if they were entirely distinct, and not at all related to the Marine, so that we may plead companionship in our crime. If we revert to the past history of the literature of British Fresh-Water Algæ we shall find this to be correct.

The historical review may be briefly summarized, by dividing it into three epochs, of about forty years’ duration for each, the first being limited by the publication of Dillwyn’s “Confervæ,” the second by Hassall’s “Fresh-Water Algæ,” and the third by Cooke’s “British Fresh-Water Algæ.”

Prior to the first epoch there were but two works of sufficient importance to be mentioned here—Ray’s “Synopsis,” which was published in 1724, and Dillenius’ “Historia Muscorum” in 1741. Each of these, as far as they can be identified, included somewhere about 20 species of Fresh-Water Algæ.

The epoch commences in reality with Hudson’s “Flora Anglica,” the first edition of which is dated 1762, and contains about 25 species. Then came the first edition of Withering’s “Arrangement of British Plants” in 1776; Lightfoot’s “Flora Scotica” in 1777,
also with 25 species; Robson's "British Flora" in the same year, with 26 species; the second edition of Hudson's "Flora Anglica" in 1778; Relhan's "Flora Cantabrigiensiis" in 1785, with 12 species; and Sibthorp's "Flora Oxoniensiis" in 1794, with 7 species. This brings us to the third edition of Withering in 1796, with 38 species; followed by Abbot's "Flora Bedfordiensis" in 1798, with 14 species; and Hull's "British Flora" in 1799, with 34 species. These were all the predecessors of Dillwyn, and did not achieve much for the Fresh-Water Algæ until the climax was attained by the publication of Dillwyn's "British Confervæ" in 1809, with 88 species enumerated. The first edition of "English Botany" had already commenced in 1790, extending to 1814, but it was not until after the appearance of Dillwyn's work that the Algæ of the British Botany were published, ultimately including about 100 species. Undoubtedly Dillwyn was, therefore, the parent of a systematic study of the British Fresh-Water Algæ, and with him the first epoch culminated.

The second epoch commenced well with the continuance of "English Botany," and then followed several botanists whose influence has passed down even to our own times. Following the example of the first epoch, we may enumerate the most important of their works. The "Midland Flora" of Purton in 1821 only includes about 14 species. Hooker's "Flora Scotica" in 1821, about 39 species; Gray's "Arrange-
ment" in 1824 was confessedly devoted chiefly to systematic classification, including nominally 103 British Fresh-Water Algae. Greville’s “Flora Edinensis” in 1824 had 50 species, the working period for Algae having scarcely commenced, his “Algae Britannicae” appearing in 1830. Jones and Kingston’s “Flora Devoniensis” in 1829 included but 29 species. Johnston’s “Flora of Berwick-on-Tweed” in 1831 had 40 species. Near this time (1833) Berkeley’s “Gleanings of British Algae” was published. The latter volumes of “The English Flora” appeared also in 1833, under the editorship of Sir William Hooker, the Algae being contributed by Dr. W. H. Harvey, and included 160 species. This was Harvey’s first important contribution to the History of British Algae, which was succeeded in 1841 by the first edition of his “Manual,” containing 198 fresh-water species. Between these two Mackay’s “Flora Hibernica” was issued in 1836, with 87 Irish species. These all culminated, in 1845, in the appearance of Hassall’s “Fresh-Water Algae,” enumerating 297 species, exclusive of Characeae, Desmidiaceae, and Diatomaceae, thus closing the second epoch. The time at which this latter work appeared was an active one in British Fresh-Water Algae. Ralfs was preparing his work on Desmids, and contributing papers to the scientific journals, notably the “Annals of Natural History.” Dr. Greville had commenced his “Scottish Cryptogamic Flora” in 1823. Harvey was at work earnestly with
Marine, and of course casually with Fresh-Water Algae. The volume containing the Algae of the "English Botany," second edition, appeared in 1844, so that about this time, which we distinguish as the end of the second epoch, characterized by the publication of Hassall's work, there was greater promise than came to be realized in the early part of the next epoch.

It is not uncommon to hear observations made disparagingly of the work with which the second epoch closed, when no account is taken of the difficulties which had to be encountered in preparing an illustrated work of that nature. It cannot be fair to judge it by its successors, but by its predecessors, and if it was fairly up to the general standard at the time of its production, that is all we can expect. It must be remembered that Kutzing's large and splendid work, the "Tabulæ Phycologiae," was only commenced in 1846, and that therefore it could not be consulted. It is certainly to be regretted that in Hassall no indication is given of the measurement of the objects figured, or the magnification employed. That there are faults no one will deny; but, on the whole, we are not prepared to condemn it as unworthy of the time at which it appeared. A comparison of the figures of Desmids with those in Ralfs' work, of but three years later, will show that in execution something was left to be desired.

The third epoch is one on which we must necessarily
be very brief. Coming so near our own time, we must be content to indicate what has been done, and leave conclusions to others. Closer relations with the Continent, cheap postage, more general acquaintance with foreign works, all tended to raise greater expectations for the closing work of the third epoch than any of its predecessors. The works of Kutzing, the Memoirs of Pringsheim, De Bary, Cohn, Bornet, Thuret, Borzi, Wittrock, and many others, all contribute to illustrate British Fresh-Water Algae; and although during forty years very little has been done in our own island, even in the identification of species, there has been considerable activity in investigation, especially in the North of Europe. The scattered memoranda, notes, and observations of Professor Henfrey, Dr. Braxton Hicks, and Mr. W. Archer constitute the bulk of our home manufacture of the literature of Fresh-Water Algae for about thirty years. The later portions of the "Supplement to English Botany," containing Algae, date from 1843; and Harvey's second edition of the "Manual," in 1849, was wholly confined to Marine species. Hence there is not an independent work on British Fresh-Water Algae belonging to this third epoch, until we come to its close, the only contributory work being Berkeley's "Introduction to Cryptogamic Botany," in 1857. But if there was an extraordinary dearth of books on this subject after 1845 in Britain, such was not the case on the Continent. The consecutive publication of the volumes of Kutzing's
"Tabulae" must have been an important influence, although it was not until 1864 that Rabenhorst's "Flora Europae Algarum, Aquae Dulcis et Submarinæ" was commenced. The advent of this work was hailed with pleasure, notwithstanding its many faults; and various authors set themselves to work on different genera and families, such as Ædogoniaceae, Zygnemaceae, etc., so that in twenty years it is left far behind. As a work written in English, although not containing much original observation, we must mention Dr. Horatio Wood's "Fresh-Water Algæ of North America," published in 1872, which was at length superseded by "Fresh-Water Algæ of the United States," by the Rev. Francis Wolle, in 1887, or within four years after the completion of "British Fresh-Water Algæ," by M. C. Cooke, which we have taken as the close of the third epoch of our brief summary. This latter work contained 445 species, as against the 297 species included in Hassall's "Algæ," and a few species since discovered would raise the total to about 450 species, all told, although some of these must be excluded as "doubtful Algæ."

The history of the changes which have taken place during fifty years in the location and interpretation of most of the Fresh-Water Algæ will have but little interest for the general reader, who will not concern himself that the majority of species were formerly Fucus, Ulva, or Conferva, or that the Nostocs were joined with Tremella and thus linked with Fungi.
Possibly, in respect to the latter, he will hint at the irony of fate, which threatens to associate *Nostoc* again with *Fungi*, in somewhat degraded relations of commensalism. Here, again, it is rather the duty of an author to give a record of facts, than to concern himself with theories, either in support or controversy. The unfortunate tendency to the multiplication, often inordinately and recklessly, of technical nomenclatures for trivial differences, which characterizes most of the recent text-books in biological science, will have little sympathy with those who desire the extension and popularization of Natural History studies.

In times still within the memory of living men, it was not difficult for any one person, with a moderate amount of leisure, to pursue with advantage the study of two or three cognate subjects, but many things have conspired to render such a course at present unadvisable, if not impracticable. Specialism has become more and more the order of the day, so that, instead of meeting constantly with students devoted absolutely to general algology, and capable of holding their ground with Marine Algae and Fresh-Water Algae, including both Desmids and Diatoms, we find a growing tendency to split up even these into sections; hence no one feels it to be an imputation on his mental capacity to confess that he confines his studies to Desmids, or to Diatoms, or to the Fresh-Water Algae, exclusive of the latter, and, if not to the whole scope
INTRODUCTION.

of Marine Algae, to content himself with the Florideae. Not only has a process of subdivision become absolutely necessary, on account of the increase in the number of species, but also by reason of the great extension of the literature of each subject, which has to be mastered; the more intimate and searching investigation which each species demands, and which improved microscope power has fostered; and the tendency to trace the whole life-history of the several organisms, which is wholly incompatible with a wide and almost unlimited field of operations. Considerations such as these have led to the production of books like the present, which endeavour to limit the scope of investigation within attainable boundaries, and, by the selection of well-defined groups, offer, within a reasonable compass, a "guide, philosopher, and friend" to assist in the pursuit of a scientific study which shall be recreative and not oppressive, circumscribed and not illimitable.

Introductions have been written and published to Cryptogamic Botany as a whole. We have had Introductions, or Handbooks, to the study of Mosses, of Lichens, of Fungi, and sections of Fungi, and also for the Marine Algae, but hitherto nothing has been attempted in this direction for the subject of the present volume. The only substitutes are too voluminous and expensive for the youthful student of limited means. If excuse were needed, this would be sufficient; but it may be added thereto that, even in the larger and more expensive books alluded to,
INTRODUCTION TO FRESH-WATER ALGÆ.

there was practically no introduction, and all the information on the rise, progress, and development of the various forms was scattered through the volumes, whereas it is now collected and arranged at the commencement.

The periodic outcry against systematic Botany, and the varied attempts which have been made and continue to be made against it, urging its inferior position and value, are senseless and unjust. There would be no science of Botany without it, and the systematist would by no means seek to exclude physiological investigations which could assist but not hinder in his work. The only danger is in seeking to elevate the one in public esteem to the depreciation of the other. It is by no means an unusual experience to meet with individuals who will condemn that which they do not comprehend, or with which they fail to sympathize, in order to cover or excuse their own ignorance. An effort to combine the two phases within the scope of one work may possibly fail to satisfy extremists, but will commend itself to the judgment of the student in search of information.
CHAPTER II.

COLLECTION AND PRESERVATION.

The earliest and most elementary process in regard to any organisms must be their recognition as members of the group under investigation. In this instance the objects are Algae, and hence it seems imperative that the first step taken should be to recognize a few generic types as representatives of what kind of objects they are. This is not a difficult task, since, from a dipping of pond-water, the tiro will soon discriminate the algae from the infusoria, even though, like Volvox, endowed with "perpetual motion." Therefore, to commence with a few hints and instructions as to the collection and examination of algae, appears to us the most natural method of leading into the subject. It is only reasonable to suppose that the first impulse of the would-be student will be the ocular demonstration of what is an alga, and that he will be desirous at the outset to collect sundry little bottles of ditch-water, in the hope that some of them will contain objects of which he is in search. It may be taken for granted that every person of education
and intelligence, in these latter days, is able to manipulate with the microscope, so that, the objects once secured, the progress of examination will succeed uninterruptedly, and culminate satisfactorily. Of course there will be failures at the commencement, and disappointments, but all these will receive full compensation in the ultimate successes. Even the town-dwelling recluse, who hardly comes within sound of a babbling brook once a week, may hazard the experiment of exploring the green slime on a water-but, the shining treacley stains at the base of brick walls, or the thready filaments floating in an old horse-trough or around a dilapidated pump, and amongst these acquire first experiences with the new "hobby."

The collection of fresh-water algæ can scarcely be undertaken without some previous notion, however vague, of localities in which they are to be found. It must not be assumed, as a positive fact, that these organisms are only to be found in water, because there are many of the unicellular algæ which are effused, like a slimy coating, on rocks subject to dripping water or continuous moisture. Some occur on the trunks of trees, where water trickles down from the branches, or even at the base upon the ground. Greenhouses and conservatories will generally show the traces of some of them on the walls, or stains upon the floor. Some of the commonest sights in damp weather are the dark patches and streaks on the
ground at the base of walls, indicating the presence of some *Oscillaria*. After plentiful rain gelatinous lumps of *Nostoc* flourish in the morning on garden walks, but dry up and shrivel into nothingness as the day advances. Even dripping aqueducts, cattle-troughs, leaky pumps, and all situations in which there is a constant percolation of water, should be explored. And, last of unsuspected places, may be mentioned the damp surface of naked soil, or swampy places in lawns, and on heaths or moors. The most usual, and one might say legitimate, habitats of fresh-water algae will be in the water, in sluggish or stagnant ditches, but by preference in ditches which are not stagnant, or at the least have no stagnant odour, slow-running streams, and lakes, moor-pools, ponds, canal-banks, attached to timber or stones, on twigs, sticks, and stems, which have for some time been immersed in water, and amongst bog moss in swamps, especially where there is a little depression and a miniature pool of clear water is extemporized. Swift rivers, torrents, etc., will be found valueless, or never repay the time employed.

General suggestions only can be made on a subject of this kind, and experience will soon suggest a likely spot for exploration, but it must always be a moist one, and continually moist, or at least for the greater part of the year. As to the period when the most persistent efforts should be made for the collection of algae, some indication will be expected, and yet, for
our own part, we should not relax at any period of the year, except, perhaps, when the ground is covered with snow, because we have often broken the ice upon a pool and dipped out water containing interesting forms. It may be cold work, but is sometimes well rewarded. As may be anticipated, algæ are not in the same condition all the year, and even the same species collected about February would have a different appearance, and be in a different condition from the same species collected in June or September, especially the filamentous kinds. It may be taken for granted that all species are not in fructification at the same time. Perhaps *Spirogyra* will be found in fruit, or in conjugation, in spring, and most species of *Cedogonium* not until the autumn. So that something may be collected at all seasons of the year. The novice may be reminded that he will save himself a world of trouble, anxiety, and vexation, if he abandon all endeavour to identify species of algæ which exhibit no trace of fructification. Long filaments of regular cells, differing only in length and thickness, may look pretty enough, but in that condition they are of little interest to the student who desires to become acquainted with algæ upon scientific principles, and not empirically. The only way in which they could give promise of becoming useful would be by committing them to small aquaria or tanks in order to watch their growth and development.

Some provision has to be made even for a short
stroll in search of these organisms. The requisite apparatus is small and by no means cumbersome, but if the excursionist desires to prove himself a sane man, rather than a reckless enthusiast, he will take good care that his boots are good—not of the drawing-room pattern, but good substantial boots, intended to keep all the moisture on the outside. Wet feet are by no means pleasant to one's feelings, even without fear of rheumatism, or colds in the head, as a remote contingency. The sensible naturalist will have less regard for personal appearance than for personal comfort. Young men, like young ladies, dislike to be caught in deshabille, until they discover that kid gloves and patent-leather shoes are not the essentials of field work. In order to be prepared for dipping out the water of a pond, and examining its contents for floating algae, a dipping-bottle, with a wide mouth, will be requisite, and with it a brass collar fitted to the end of a walking-stick. A pocket lens, with about one inch focus, must be provided for casually examining the water when dipped out of the pond. This hint should be quite unnecessary, for a true naturalist would as soon think of leaving his home without his boots, as without his inevitable pocket lens. Handy collecting-boxes can be purchased, holding a dozen small tubes with corks, into each of which consecutively the results of dippings for the floating algae may be transferred. Filamentous algae can be folded in small squares of thin gutta-
percha, or even in paper, and conveyed home for examination. Slimy algae, encrusting rocks and stones, can be removed by the aid of a strong knife, and stowed in paper or tin-foil. They may even be sent by post to a distant friend in the same manner, and be quite fresh at the end of a long journey.

Most smokers are aware of the existence of small metal match-boxes, which, when freed from their original contents, are available for stowage of such algae as Nostoc, and even of Batrachospermum and filamentous algae in general. The specimens will keep moist and fresh for some days, and the boxes will occupy but little space in the pockets. After a day's collecting, it may be well to transfer the contents of the various bottles and boxes to small white artist's saucers, with a little water, and examine each at leisure.

A sort of cultivation may be carried on by the means of a series of tumblers, each restricted to its own particular gathering, and every one raised a little above its fellow, and connected with it by a thread, so that, like a syphon, water flows through the whole series in a slow gentle stream. Of course the first, or upper, tumbler will be supplied by a constant drip, and waste from the last, or lowest, tumbler will be carried off into a jar or similar receptacle. By this means, specimens collected in an immature condition may pursue their growth and development, and a constant source of amusement and instruction be pro-
vided for a wet day or a leisure evening. Those who do not like the trouble of so many receptacles, and can carry out all their designs upon a simpler scale, adopt a single inverted bell-glass, converted into an aquarium, into which all species are cast pell-mell, and flourish in concert. Certainly a very heterogeneous assemblage may be obtained in this way, and for the purposes of most people this will be sufficient. There will be no lack of objects, animal as well as vegetable, and, with a little management, such an aquarium may be kept sweet and prolific for a lengthened period.

Preservation for the herbarium, or for future study, may be secured by the usual methods of floating and mounting marine algae, first cleansing the specimens (where practicable) by well washing in a flat dish or soup plate, and finally passing under them a slip of clean white paper, which is raised so as to take up the algae in the middle, well floated into position, draining off the water, and then drying, with the least pressure possible. In some cases, where the algae are gelatinous, no pressure at all must be used until the algae are partially dried, or the papers will be firmly glued together. Some prefer placing a thin fine muslin over the specimen, before laying down the upper sheet of paper, to prevent adhering. For minute species and small specimens, thin flakes of mica are preferable to paper, for many reasons, especially that they can be placed at any time under the microscope and examined. The Palmellaceae, and
similar groups, will be of very little service if dried in any other way. Most species will adhere of themselves to either paper or mica; the exceptions, such as Vaucheria and some Cladophorae, can be fixed with gum tragacanth. It must not be expected that the fresh-water algae will make pretty objects when dried, in the same manner that the red seaweeds are beautiful. Indeed, with very few exceptions, they will only present themselves to the naked eye as discoloured blotches or a congeries of green threads. On the other hand, they have their utility in the midst of their ugliness, for, whenever moistened, the cells will swell again, and something of the old form will be restored, although in most cases the bright green chlorophyll will have disappeared. No one would attempt to preserve them in this way for their beauty, but simply for evidence and comparison, and other cases of utility.

Some difficulty may probably be experienced in mounting specimens for the microscope. Every one has had to struggle more or less through these difficulties. We have seen "slides" in which the specimens were still green and life-like, after having been mounted for twelve years in the water in which they were collected, but unfortunately there is always a risk of leakage in mounts with fluid. If the medium is denser than the contents of the alga-cells, the endochrome will be contracted and the walls collapse. One objection to mounting in glycerine, or glycerine
and water, is the density of the medium, and consequent collapse of the cells; another, that in time, use what precaution you may, the cells will leak, more or less, and the object become dry. No medium has yet given us absolute satisfaction; but, all things considered, we are most favourably disposed towards glycerine jelly, which is too dense to enter the cells, and does not alter the form more than glycerine would do. We may add that slides should always be flat in the cabinet, and not on the edge; and they should not be left exposed to the light, or the green colour will soon be lost. We have in most vivid recollection a large collection of fresh-water algae, consisting of some hundreds of specimens, mounted by a most competent German algologist, and which would, if permanent, have been invaluable. These were mounted on squares of mica, covered with mica, or in some instances on glass, covered with mica. The fluid was some combination of glycerine, consequently not one specimen in fifty is of the slightest value whatever, so that a vast amount of skilled and intelligent labour has been thoroughly wasted, giving no advantage to any one, and no satisfaction to any one, but is a permanent source of disappointment and regret.

Whether in the case of specimens dried for the herbarium or preparations mounted for the microscope, experience has taught us to urge upon all students the very great importance of attaching to the object certain information which may be found invaluable
in the future, although of little moment at the present. The first item in this information should be the locality where the specimen was collected, because localities are of considerable value in ascertaining geographical distribution, in drawing up local lists, and, having regard to the changes which the extension of large towns, the encroachments of the house-builder, and the destructive drainage pursued in public parks, and open recreation grounds, have upon small ponds and pools, swampy places, and, indeed, almost all habitats where fresh-water algae are chiefly found, it is of the utmost importance to secure evidence of the existence of all species in such localities, which may be doomed in the near future to become obliterated. Another item of possible interest would be the addition of the precise date of collection, because this will not only fix the year when the course of nature had not been diverted by the encroachments of civilization, but, by being precise as to the month and the day, it will serve to indicate the precise period when the particular species was found in any stage of fructification. It is by no means certain when the majority of species should be sought after, if it is desirable to obtain them in mature fruit, hence the accumulation of evidence of this kind may prove of value in the future, and only requires a due appreciation of its value to make its acquisition sure. It may seem unnecessary to those who are experienced in the collection of these organisms to urge such points as
these upon the student, and more unnecessary still to append one or two cautions, which we deem prudent to suggest. Young collectors are likely to select, for instance, the brightest green tufts of filamentous algae seen floating in a clear pond, under the impression that such tufts will exceed all others in beauty. This is a false impression, for specimens of that kind will be in most vigorous growth, will exhibit all the glories of exuberant vegetation, but will be deficient in fruit, whereas the accurate determination of species depends almost entirely upon the fructification. Older, duller, discoloured tufts, less pleasing to the eye, will prove the most valuable, because of the greater probability that they will carry evidence of fructification. It is a common mistake to suppose that the filaments of any confervoid alga, in any condition, can be readily determined by an adept, whereas the fact remains that the expenditure of time and patience on the attempts to identify sterile threads or fragments is absolutely wasted, except in connection with fruiting specimens, or when the phenomena of vegetation alone are the points in question, without reference to absolute identity of species. Another suggestion may be offered as to the value or interest of examining carefully the old, and apparently exolete, threads of decaying tufts. When all the vitality and beauty has departed, these old threads may become invested with a new interest by reason of the small parasitic species which establish themselves upon them. Such species will probably
never be met with except under such conditions, and therefore these should be sought after diligently, under the conditions most congenial to their development. *Mischococcus* is one of these parasitic species.

There is still another suggestion which relates to making the most of one's opportunities. This applies to acquiring facility in the practice of camera-lucida drawing. Without staying to discuss what particular form of camera should be employed, whether a single glass disc or a more complex prism, for this is beyond the question, and may be regulated by individual judgment and experience, the main point is to urge that some method should be adopted of throwing down the image upon a sheet of paper, so that the outline can be traced. It will often happen that some peculiar condition of cell-formation is met with, or some stage of conjugation or fructification encountered, which it is desirable to remember, and this is best done by at once making a drawing by the aid of the camera-lucida. Wise persons are in the habit of making such sketches of cells, or spores, for the purposes of securing accurate measurement of their dimensions. Microscopists need not be told that it is quite possible to construct carefully a scale of measurement, whereby the image of any object, accurately traced, can be measured correctly and with facility, so long as the conditions of distance, position, etc., are adhered to. This is really a point of microscopical manipulation, and need not be expatiated upon, whilst
urging the value of making sketches and cultivating, by practice, facility in its accomplishment. No previous knowledge of drawing is essential, although it might be useful, and early difficulties are not insurmountable, although there are difficulties at first, and until the eye and hand are educated to the task they have to perform. All living objects will present certain features which vanish on dessication, and the only way to secure representation of them is by camera-lucida sketches.

The most elaborate instructions would be useless, in connection with this or any other subject, unless they are met by a corresponding earnestness and perseverance on the part of the student. A certain amount of enthusiasm must be imparted to every pursuit of this character, and this enthusiasm will grow as the initiatory difficulties vanish. That there will be difficulties at first, no one can deny, but application, experience, and resolution will prove the best antidotes. "It is the first step which costs," is an old axiom, applicable here as elsewhere, and when the early steps are taken the succeeding ones will become less and less difficult, more and more gratifying and satisfactory, until the fascination of success will lead on to the full fruition of a work which, ceasing to become a work, attains to the position of a pleasure, which will amply repay for all the labour it has cost.
CHAPTER III.

CELL-INCREASE.

The multiplication of cells by subdivision is the simplest form of increase in such organisms as the fresh-water algae, and whether, in unicellular species, we should regard this as a simply vegetative process, or a low form of reproduction, is practically of very little importance. Being disposed to regard it in the light of a vegetative process, we place it under the above heading, as a prelude to the more determinate cell-increase of filamentous forms hereafter described.

In the majority of unicellular algae the only known mode of increase is by the ordinary process of cell-division. In such cases the contents of the cell divide in one or both directions, into two or four daughter-cells, and a septum is set up between them by the secretion of cellulose over the whole surface, the flat adjacent surfaces gradually recede and become rounded, until the mother-cell encloses two or four daughter-cells, which, on the rupture of the membrane of the parent-cell, escape as individual plants, in all respects like the parent from which they sprang.
In this manner a perfect colony is formed, each of which in turn becomes a mother-cell. Sometimes they are held together in a kind of mucilaginous thallus, and sometimes they are free. In certain cases the cell-membrane is increased by successive deposits which appear like concentric rings, until the hyaline investment is considerable; and in other cases there is, apparently, only a simple investing membrane. This is the entire process of rejuvenescence in some simple forms of algae, if they are to be regarded as autonomous plants, which is now being called in question.

The Palmellaceae and the Chroococcaceae furnish illustrations of this mode of increase, which Braun has characterized as "reconstruction of the cell," and he says that, "if the transformation of the entire cell-contents is combined with a division of them, a multiplication of the cell takes place, constituting the basis of the formation of tissues in plants where the cells remain connected together, multiplication of the individual where they separate. In the majority of cases the entire contents, that is to say, the whole active living organism of the cell, passes directly into the new structure, so that nothing remains behind, unchanged, of the old cell (the mother-cell) except the passive membranous wall. The daughter-cells are therefore not to be considered as young produced by the mother-cell, existing contemporaneously with it, nourished by and gradually developed in it, but as the
rejuvenized and metamorphosed mother-cell itself. This is most strikingly evident in those cases where the entire and undivided cell-contents become loosened from the membrane of the mother-cell, and, shaping themselves in a different way, become a new cell.”*

In *Tetraspora* the cell-contents divide in both directions, and as the quaternate divisions separate (Fig. 8) they continue in the same position of proximity within the frondose thallus, so that the daughter-cells lie in groups of four, which originated the generic name. In the *Palmellaceae* and its allies many undoubted cases of true quartering, or apparent quartering, may be met with. In *Protococcus* mere halving and true quartering have been observed intermixed. In some generations no true cell-membrane is developed, only a gelatinous envelope. And where a true cell-membrane exists, it sometimes splits and is cast off after subdivision, as in the genus *Schizochlamys* (Fig. 3). The globose cells of this alga “produce a hyaline cell-membrane, which becomes removed to some distance from the green body of the cell by subsequent secretion of fluid-like jelly; soon, however (probably from endosmose), becoming unable to withstand the expansion of the jelly, it splits in the direction of an equatorial circle, by a clean line, into two similar halves, or if the dehiscence takes place by two circular lines, cutting at right angles, into four similar pieces. This splitting and peeling

* Braun on Rejuvenescence (Ray Society), p. 227.
of the membrane either coincides with a division of the internal cell-mass, or it occurs without any such division. By frequent repetition of this process the cell gradually becomes surrounded by an accumulation of old fragments of the membranous shell, which are held together by the extremely transparent jelly set free. The division of the cell may be either a simple halving, in which case each part is immediately clothed again with a hyaline cell-membrane, or double, through the cells produced by the first division separating immediately into two cells, without previously acquiring a coat of cell-membrane, and therefore without skinning." Braun observed a similar tearing and exfoliation of the outer layers of stratified cell-membranes in species of *Chroococcus* and also in *Glæocapsa*.

The general character of cell-division and the formation of daughter-cells in filamentous algae is maintained, with the modification that the multiplication usually takes place in the direction of the filament, with the division, and new septum transverse to the length. A few illustrations will serve for this portion of the subject.

The process of fissiparous division of cells in *Spirogyra* was observed by Thwaites. Herein the endochrome is arranged in one or more spiral coils within the cells. "When the latter is about to become divided, a slight disturbance of the regularity of the spirals may be observed just in that part of the cell
where the division will take place; their continuity is subsequently broken at this spot, and soon afterwards the original cell may be seen to have become converted into two, with no apparent disturbance of the endochrome, except just at the point where separation took place. Various explanations have been given of the mode in which the division of the cell takes place, but I believe the correct one is to consider that each half-endochrome develops around it a new cell-membrane, the old one remaining or becoming absorbed.”

It has also been observed by the same writer how cell-division takes place in Cladophora glomerata. “In this species the cells are extremely large, and the endochrome is in considerable quantity; and the cells apparently continue increasing in size during the whole period of their vitality, so that those at the base of the plant are larger than those recently developed. Some species of Conferva consist only of single unbranched filaments, so that, in these, new cells are added only at one point; but in the species under consideration new cells originate from every part of the plant, and thus we have a favourable opportunity of observing what takes place when a new cell is being produced from one which has been some time developed. A slight protuberance is observed upon the cell-membrane, which has the appearance of being caused by the enlarged contained endochrome endeavouring to force its way out of the cell. This protuberance
increases at the same time with an increase of the endochrome, and becomes of some considerable length before there is any appearance of a septum dividing it from the original cell. The endochrome, however, subsequently divides, and a membrane is developed over each of the divided ends; or, what is the probable explanation, a development of cell-membrane has been taking place during the whole process, and, still going on, a membrane is now naturally formed over those ends of the endochrome where the previous continuity has been broken. That an addition is continually being made to the cell-wall is evident, since there is no other way of accounting for the increasing size of the cell and thickness of its membrane.”*

Excellent opportunities occur for watching the division of cells in *Edogonium*. In this genus the cylindrical filaments are like those of a *Conferva*, from which they may be distinguished at a glance by the transverse parallel striæ at one or other extremity of many of the cells. These striæ are indications of the mode of cell-increase, which takes place in the following manner:—“When a cell has reached maturity, and is about to divide, a little circular line is seen near its upper end. Gradually the line widens, and it is seen that the wall of the mother-cell has divided all round, and the cell above is slowly raised by the growth of the daughter-cell, arising, as it were,

*Annals and Magazine of Natural History*, vol. xviii. (1846), p. 18.
out of the apex of its parent-cell, and carrying upwards the first streak, or cap, left by the breaking away of the wall of the mother-cell. In this manner the new cell soon attains a length equal to the one from whence it sprung. When the young cell has matured it becomes in turn a mother-cell, the splitting round is repeated, a second streak or cap is carried upwards, and thus as many as four, five, or six successive cells are formed, as indicated by the four, five, or six striae or caps which may be counted at the apex of a cell, the number of caps corresponding to the number of cells produced consecutively immediately beneath the caps (Fig. 67).

"Related to this subject of vegetative increase is the known fact that some species of algae possess power of compensating for injuries by abnormal methods. Thus, when the filaments of Vaucheria remain in a purely vegetative condition, they are without septa, but if a filament is injured, the protoplasm in the neighbourhood of the injury contracts, and a septum is formed, shutting off the injured part. Schaarschmidt affirms that while this is the case, the filaments no longer have the power of reproduction; that they break up into gemmæ, or buds, which remain for a longer or shorter time in that condition, and then germinate, producing new filaments. Gemmæ, he says, are also formed on uninjured filaments, going through a great change of form before germination. A similar power of re-
juvenescence has also been observed in *Conferva bombycina*. A portion of the contents of the injured apical cell invests itself with a double membrane, and separates itself from the injured cell.”*

It may be remarked in passing that there are not uncommonly found to be septa thrown across the threads of *Vaucheria* which cannot be accounted for by the above phenomenon. The normal condition of *Vaucheria* filaments is that of continuous cells, without septa, but it is not yet explained why an abnormal condition should so often be met with, even in comparatively young threads, which have never been injured, and yet in which distinct septa are visible. Not only have we had ocular demonstration of this ourselves, but attention has been drawn to it by various correspondents, and yet we have found no opportunity of searching further for the cause or explanation.

CHAPTER IV.

POLYMORPHISM.

The suspicion that amongst so-called species of the fresh-water algae there were some, and probably many, which were not stable, soon took possession of the mind of those who were working at this subject. With the advance of knowledge suspicion is ripening into certainty. When Berkeley wrote, more than thirty years ago, he expressed this feeling. "It is very doubtful how far many of the supposed algae, such as Glæocapsa, are autonomous species. Where a plant bears fruit, and is reproduced by that fruit, there can be little doubt that a species is true; but where all the propagation is a simple repetition of the division of the endochrome, as in Glæocapsa, there is some room for doubt. Mr. Thwaites, in the course of his investigations, was led to suspect that many of these lower algae, however beautiful and interesting as microscopical objects, were not autonomous; many seemed to pass into each other by intermediate forms, and some were so constantly the attendants of others,
as *Palmellae* of *Sirosiphon*, that he was led strongly to suspect very close and intimate connection.*

Nearly all who have of late studied these low forms have come to the conclusion that amongst them are a large number of so-called species which are merely conditions of other algae, and ultimately a thorough revision will be imperative, dependent upon a knowledge of the life-history of each species. Richter, in 1880, published some observations upon *Glæocystis*, in which he contended† that this genus has a form of development consisting of cylindrical cells, which may be encysted or free, and which alternate with the familiar spherical encysted form; a Palmella condition with tetrahedral divisions occurring also within the latter. The first form is termed the *Cylindrocystis* condition. Each of these forms may be developed from another, so that *Glæocapsa*, *Cylindrocystis*, and *Microcystis* are probable synonyms of *Glæocystis*. By this means four genera, so called, will be resolved into one.

Subsequently the same author suggested‡ whether various forms of unicellular algae, for some time considered to be distinct, and ranged under the genera *Glæocapsa*, *Chroococcus*, *Aphanocapsa*, *Glæothece*, and *Aphanothece*, are not really genetically connected, displaying a kind of polymorphism; a form with but

slightly encysted cells (as *Aphanocapsa*) intervening between one with encysted spherical cells (*Glæocapsa*) and one with encysted cylindrical cells (*Glæothece* and *Aphanothece*). Thus *Aphanothece caldariarum* presents an intermediate form between that genus and *Glæothece*, and would appear to be completed in its cycle with two other forms, called respectively *Glæothece inconspicua* and *Aphanocapsa nodulosa*, being a maturer condition of the first of these two. In like manner *Aphanocapsa biformis* is shown to occur in three different forms. Here, then, is a very strong indication of polymorphism amongst related genera.

In this communication, the following conclusions are arrived at. Amongst the *Phycochromaceae* the lowest form is the naked *Aphanocapsa* condition, which corresponds to *Palmella* amongst the *Chlorophylophyceae*. From this naked, or but little encysted condition, is developed the *Glæocapsa* or *Glæocystis* form, with several gelatinous envelopes; the *Chroococcus* type, wherein the investment is altogether wanting; or, when there is only a single vesicular envelope, the cœnobium types. The *Glæocapsa* type is specially adapted for exposure to the air, and growth upon a comparatively dry substratum; the cœnobium type is developed in water; the *Chroococcus* type in water, or a moist substratum. With this is connected the cylindrical form, a higher state, showing a development towards the filiform condition.
This is not always developed, and may be divided into stable and unstable forms. The latter may occur in two or three varieties, and go through the following successive conditions:—

1. Stable *Aphanocapsa* and *Palmella*.

2. *Aphanocapsa* and *Palmella* which have attained to *Glaeocapsa, Glaeocystis*, or coenobium type, but which always revert to the naked solitary spherical form.

3. Stable *Glaeocapsa, Glaeocystis, Chroococcus*, and coenobium forms, without reversion (*Merismopedia*).

4. Cylindrical forms, the generations of which pass through the solitary spherical (*Aphanocapsa* and *Palmella*) conditions, as well as the *Glaeocapsa* and similar forms.

5. Cylindrical forms which pass through only the *Glaeocapsa* and similar forms.

6. Cylindrical forms, the generations of which revert to the *Aphanocapsa and Palmella* condition, while the *Glaeocapsa* or any similar form is suppressed.

7. Stable cylindrical forms (*Synechococcus*).*

These dry details are sufficient to show that, amongst a large number of simple unicellular forms, polymorphism is admitted to exist to a considerable extent. Kirchner has declared his belief that "the genus *Protococcus* contains a number of heterogeneous forms, of which certainly the most, if not all, are

developing forms of higher algæ, as copulating microspores, resting macrosores, or products of a peculiar disintegration of filamentous plants;" and the Rev. F. Wolle says, "I reason from analogy and say that all the forms of Pleurococcus, Protococcus, Chlorococcus, Glæocapsa, etc., belong to and are mere developing forms of higher algæ. I have had such positive evidence of transformation, I cannot think otherwise." This latter author and some others contend that the common green form of Pleurococcus may be traced to a filamentous condition, and that therefore the Pleurococcus is only an imperfect unicellular condition of some Ulothrix or other confervoid alga. The researches of Dr. Braxton Hicks* not only confirm these views, but carry them still further; for he contends that certain species of Ulothrix, Schizogonium, and Prasiola are but developments of the Pleurococcus form, and are indeed but one polymorphous species. Two or three quotations will explain the position.

"If we observe a batch of Lyngbya (Ulothrix) in its first appearance in spring, and also at other times, we shall find many of the threads throwing off from one extremity its terminal cells, which, relieved from pressure, become globular. Watching these, and carefully tracing their history by keeping them under

continuous observation, I find that they undergo segmentation in the same manner as the so-called *Palmellaceae*. It will be seen that this process assumes the same type as prevails in the gonidia of lichens, proceeding in various manners until, in some instances, the subdivisions are very minute. By means of this gonidial increase, considerable surfaces are covered with a palmelloid growth, and it has constituted one of the forms included under the term *Protococcus viridis*, and thus gives another example of the temporary nature of that order.”

He then proceeds to describe how these small cells assume the linear form of segmentation and become threads. Taking up the mature thread, he shows the strong tendency, under certain circumstances, for cell-division to extend laterally instead of lineally, so that there appear to be two threads side by side. Then, by extension of the same process, a band is produced of four rows of cells, or more, etc.

“Thus it will be remarked that a constant struggle is going on between the linear and lateral mode of growth, and between either of these and the gonidial, with its changes; the balance seeming to be always uncertainly suspended between them.” Thus he claims to have pointed out the following series of existences:—

1. The mature *Ulothrix*.
2. Its gonidia and their segmentation.
3. Their recurrence to *Ulothrix*.
4. The lateral segmentation of the cell of *Ulothrix*,
in part or wholly, passing ultimately to the formation of broad wavy fronds, the cells being held together by colourless intercellular substance.

5. The formation of gonidia from these fronds and their segmentation.

6. The assumption of linear growth by these cells.

"The whole of these changes are so palpable, can be observed so constantly, and are, at the same time, so simple in their relations to one another, that one can scarcely imagine how they can have been separated not only into distinct species, but into different families of algæ. Thus the linear stage is called Ulothrix; the early stage of collateral segmentation the Schizogonium; the adult stage Prasiola; while the gonidial growth has been classed under Palmel-laceæ."

"The only real difference between Ulothrix and Schizogonium is that whereas Ulothrix is a tube containing distinct cells within, which, when old, undergo collateral subdivision, to form a band of two, four, or eight rows of cells; Schizogonium is a band of two or eight rows of cells, which, when young, was but a single row, contained in a tube; which is only two different ways of stating the same facts. The comparison of Schizogonium and Prasiola is of the same kind. For as Prasiola, when old, is composed of many rows of cells, but which arose from a single row, there must have been a time in its life when it had two, four, or eight rows, and thus have been a
Schizogonium, for there is no other structural difference between the two."

"Thus it seems that we cannot but conclude that Ulothrix radicans, Schizogonium, and Prasiola are but different stages of the same organism, which, with the segmentation of their gonidia into the Palmelloid cells, form a circle of phases, each of which has a powerful tendency to recur in shorter cycles to the form which preceded it."

Cienkowski and others have seen the disintegration of Stigeoclonium and other conservæ into Protococcus cells, whilst Schnetzler * traced the cells of Palmella uvæformis into a filamentous alga, probably a Stigeoclonium, and back again by disintegration into gelatinous colonies of Palmella. Indeed, as much as this is generally accepted, so that to multiply instances or authorities is needless.

According to the researches of Woronin, instances of polymorphism occur in Botrydium, but these take such a form, and form part of a cycle, in a manner which appeared to justify us in giving extended details in our chapter on "Alternation of generations." Nevertheless the points may be indicated here, viz. that a plant placed in water, its contents are modified into zoospores, which ultimately escape, soon come to rest, lose their flagellum, become surrounded by a membrane, and germinate on damp earth, in which stage they represent the so-called Protococcus botry-

* Journal of Royal Microscopical Society (1882), p. 64.
Take another instance. If *Botrydium* be exposed to drought, the wall collapses and the contents break up into a number of cells, each surrounded by a membrane, with contents which are at first green and then red. These are called spores, and have been known by the names of *Protococcus coccoma*, of *Protococcus palustris*, and also of *Protococcus botryoides*.

Professor Cohn, at the conclusion of his treatise on *Protococcus pluvialis*, emphasizes the polymorphism of that and some other species; for, he says, "it cannot be doubted that the great diversities exhibited in the above respects, at different stages of its growth, by *Protococcus pluvialis*, exist also in other algae, if they were duly sought after, and that researches in other species, from the same points of view as those embraced in the present memoir, would probably reduce very materially the large number of genera and species of algae."

"Thus we see that a single species, owing to its numerous modes of propagation, can pass through a number of very various forms of development, which have been either erroneously arranged as distinct genera, or at least as remaining stationary in those genera, although, in fact, only transitional stages. Thus the still Protococcus cell corresponds to the common *Protococcus coccoma*. When the border becomes gelatinous it resembles *Protococcus pulcher*; and the small cells, *Protococcus minor*. The encysted motile
zoospore is the genus *Gyges granulum* among the infusoria, resembling also on the other side *Protococcus turgidus*, and perhaps *Protococcus versatilis*. The zoospores divided into two must be regarded as a form of *Gyges bipartitus*, or of *Protococcus dimidiatus*. In the quadripartite zoospores with the secondary cells arranged in one plane, we have a *Gonium*. That with eight segments corresponds to *Pandorina morum*, and that with sixteen to *Botryocystis volvox*. When the zoospore is divided into thirty-two segments it is a *Uvella* or *Syncrypta*. When this form enters the ‘still’ stage it may be regarded as a form analogous to *Microhaloa progenita*; this alga genus is probably, speaking generally, only the product of the *Uvella* division in the *Euglenæ* or other green forms. The naked zoospores, finally, would represent the form of a *Monad* or of an *Astasia*; the caudate variety approaches that of a *Bodo*.” * But, he adds, as if to guard against the prospect of misrepresentation, “it must not hence be concluded that the result of these investigations implies the existence of a state of anarchy in the domain of microscopic organisms; or that any one form among them may assume any other form indifferently; that, in fact, there are no real species in the invisible world. Such is by no means the case.”

Another instance of polymorphism, or at least dimorphism, may be observed in the *Conjugatae*.

* Professor Cohn on *Protococcus nivalis* (Ray Society), p. 559.
The ordinary form of conjugation, recognized in the time of Hassall as the only one pertaining to the genus *Spirogyra*, was the conjugation of two separate threads, by conjugating canals uniting the threads, and the discharge of the contents of one cell into the corresponding cell of the copulated thread. In another supposed genus, then called *Rhynchonema*, only one thread was concerned in the process, and conjugation was accomplished by a loop channel between one cell and that immediately below or above it. Whereas it is now known that the two forms of conjugation not only occur in the same species, but also in the same thread, and hence the old genus *Rhynchonema* is abolished, whilst *Spirogyra* remains as a sort of dimorphous genus with two kinds of conjugation, namely, the scalariform (Fig. 45b) and the lateral (Fig. 45c). In the majority of the species both forms of conjugation may be seen, and it is by no means uncommon to observe one portion of a thread in conjugation with a neighbouring thread throughout a considerable portion of its length, whilst the remaining portion is free, and exhibits lateral conjugation between the neighbouring cells of the free extremity. It can hardly be said that polymorphism exists in the species of *Edogonium*, although the genus might be called polymorphous from the fact that in the different species three modes of fructification are known to prevail; but in this case each species remains true to its own special mode of reproduction,
and the two or three forms are not found to occur in the same species. Naturally we must seek for the most pronounced conditions of polymorphism in the vegetation, rather than in the reproduction, of species; and we shall not have to travel far without encountering them.

In his memoir on *Batrachospermum* Sirodot indicates that there are three modifications of form in the species; that is, (1) the primordial condition, or prothallus; (2) the non-sexual condition, or *Chantartransia*; and (3) the sexual condition, or *Batrachospermum*. The prothallus is a kind of pellicle which covers the surface of stones, etc., on which the plant grows. It is capable of growth and reproduction, increasing at the circumference, and reproducing itself by sporules. The non-sexual form is composed of tufts of filaments, ramifying and producing sporules, analogous to those of the prothallus. Since this form can reproduce itself through a number of generations, it has long been regarded as a distinct genus under the name of *Chantartransia*. M. Sirodot believes that he has traced three species of so-called *Chantartransia* into species of *Batrachospermum*. *

In this same relationship we may refer to recent observations on changes of form in the common *Conferva bombycina*. In the normal condition the cells are cylindrical, one and a half to two times as

long as broad, but these subsequently pass through several changes by division, until at length they become not dissimilar from those in *Ulothrix*. These are again segmented in the ordinary way, daughter-cells are developed within the mother-cells, and these latter swell irregularly; the filaments become ribbon-shaped, resembling *Sirosiphon*, curve, and assume forms which might readily be mistaken for microsporiferous filaments of *Ulothrix*. The daughter-cells, on becoming free by the bursting of the mother-cell, are like *Schizochlamys*. These cells, now free and already segmented, closely resemble *Chroococcus turgidus*.

Without being prepared to endorse all that has been written by Dr. Hansgirg on this subject of polymorphism, it is impossible to ignore the position he has assumed in its entirety. It is the case, unfortunately, that most men, when absorbed by one idea, such as this, are very apt to observe all events through a distorted medium, or, at the least, to see everything in the light in which they would wish it to be seen. Nevertheless there is so much ground for belief that polymorphism prevails amongst algæ to a greater extent than is generally admitted, and that his stric-tures have a broad basis of truth. The propositions with which he sums up one of his contributions are to the following effect:—(1) "Most, if not all, of the *Schizophyceæ* or *Cyanophyceæ* are polymorphic algæ,

which occur in nature in different stages of their development, whether unicellular or multicellular, and may, under certain conditions, maintain themselves through many generations at any particular stage; their genetic connection can be proved by observation of the history of their development.” (2) “Most, if not all, of the algae hitherto included in the family Chroococccaceae,” belonging to certain genera, of which he enumerates fifteen, “are connected genetically with other more highly developed algae; that is, they are descended, by retrogressive metamorphosis, from various filamentous Schizophyceae, which pass into the unicellular condition by their filaments breaking up into separate cells.” (3) In at least ten genera of the family Oscillariaceae, he contends, “are numerous forms, most, if not all, of which are connected genetically, not only with one another, as younger and older stages, and with various Nostochaceae and Chroococccaceae by retrogressive metamorphosis, but also with others, belonging to other families, as higher developments.” (4) Several genera belonging to the family Nostochaceae “include many heterogeneous forms, which, like the Chroococccaceae, must be regarded as stages of development, analogous to certain zooglaea-conditions of the Schizomyceetes.” (5) In ten genera of the Rivulariaceae and Scytonemaceae which he enumerates, are included, according to his view, “the highest developments of various algae, hitherto mostly placed among Oscillariaceae.” (6) He suggests develop-
ments from the Oscillariaceae and Sirosiphonaceae. (7) "Some Chlorophycaceae are, like most Schizophyceae, also polymorphic algae. Most of the filamentous chlorophyll-green algae" in ten genera then enumerated, "are connected genetically with other more highly developed algae belonging to other families.” By the swelling and separation of the cell-walls, and by continuous division, there arise from the last-named, and other families of the higher algae, various unicellular algae which are placed "under the twenty-one genera thereafter named.”* This is a long indictment, which could not be set forth in full without a recurrence to too much of technicality that would be out of place in a work of the present pretensions. The above is sufficient to indicate the vast extent to which this author attributes polymorphism, and mostly amongst the fresh-water species.

CHAPTER V.

ASEXUAL REPRODUCTION.

There is a charming variety in the modes of reproduction in fresh-water algae, a variety so remarkable that its polymorphism can scarcely be equalled in any other group of plants, and yet these varied phenomena might be classed under two primary groups—the asexual and the sexual. The former group may possibly be gradually reduced in size by the discovery of sexual elements; but it is by no means uncommon for an asexual multiplication to be co-existent with a sexual method in the same species. By asexual it must be understood that we refer to a method by which the species is reproduced and multiplied, without the intervention of fecundation. Leaving out of the question the mere increase of cells, by a vegetative process, the normal method of reproduction is by the development of zoospores, mostly active, which do not pair or conjugate, and are, as far as we know, neutral. The sexual methods are more varied, and fall under several types, such as conjugation, the pairing of zoospores, fertilization by
spermatozoids, etc., to be described hereafter. There may also be a sort of interchange between the same modes, so that after one, two, or more asexual generations, one of a sexual character intervenes, and there occurs a practical alternation of generations. All this complicity necessitates a somewhat extensive purview of reproduction, which cannot be dismissed with a few general observations, as, indeed, the phenomena of reproduction are the most important, and always the most prominent in the life history of these lowly organisms.

In *Apiocystis Brauniana* the young zoospores attach themselves by the ciliated end to *Cladophora* and other objects, and become invested with a club-shaped enveloping membrane. The first division of the green body then takes place in the direction of the axis of the vesicular envelope, and is repeated alternately in each direction of space. During this the vesicle in which the cells lie continually expands, and generally becomes very evidently produced below into a stem. Young vesicles contain a regular number of cells, namely, two, four, eight, sixteen, thirty-two, etc.; but the number afterwards becomes indefinite, in rather large vesicles attaining about three hundred, and in the largest about sixteen hundred cells.

The cells, or gonidia, are at first uniformly distributed over the whole cavity of the vesicle. Subsequently, they generally become collected on the internal surface of the wall of the vesicle, where they
ASEXUAL REPRODUCTION.

lie in one or more strata. But the cell-division always takes place in all directions of space, the cells situated internally advancing outwards towards the periphery. In old vesicles the cells are sometimes arranged in rings of eight upon the wall. When the family of cells is mature for swarming, which may occur at very different sizes, and with very different numbers of gonidia, the cells begin to move, at first slowly, from their places, and then gradually to circulate more rapidly in and out and about each other; the vesicle bursts, and the gonidia emerge by the orifice which is formed. Sometimes the swarming is preceded by the state in which the cells are arranged in parietal rings. *

The most simple and ordinary form of asexual reproduction is that in which germ-cells, or zoo- gonidia, are formed within certain privileged vegetative cells of the parent plant. This is exemplified in such genera as Draparnaldia, Stigeoclonium, and Chaetophora. In these genera the terminal cell of the branches, or sometimes some intermediary cell, exhibit their contents differentiated into a more or less large number of ciliated germ-cells, and these escape through a pore or rupture into the surrounding media, and for a time enjoy a free existence. In the comparatively recent genus Pithophora the process is somewhat similar. The upper part—about half—of the mother-cell is somewhat widened. The green contents in the

lower half of the cell pass, little by little, into the upper or widened part of the cell, until that is quite filled with the green protoplasm, whilst the lower part is nearly emptied. Then a transverse division, or septum, is gradually formed just below where the widening of the cell commences, and when this is completed the original cell has become separated into two cells, the upper of which is filled with green contents, the lower being nearly empty (Fig. 66). The upper cell ultimately becomes the spore. Its shape is cask-like, or rather cylindrical. When the membrane of the spore has attained the requisite thickness, the spore reposes for some time before germinating. As to its origin, being neutrally formed without fecundation, it has been termed an agamospore. Spore-formation may take place in all the cells of the upper, or cauloid, portion of the plant. As a rule it begins in the youngest, which are the terminal cells, proceeding downwards. In this manner one neutral generation follows another in an uninterrupted series, without any alternation of generations or fecundation.*

Asexual reproduction takes place sometimes in *Edogonium*, although some form of sexual reproduction is the prevailing rule. It occurs by the formation of a single zoospore in one of the cells of the filament. This body is globose or somewhat ovate in shape, furnished about the apex with a tuft of vibratile

* Wittrock, "On the Development, etc., of the Pithophoraceæ."
cilia. When this zoospore becomes matured it escapes by the splitting or rupture of the containing cell, and floats about for a little while, impelled by the movable cilia, and at length becomes attached by the ciliated end. Growth soon commences, and the located zoospore develops into a young plant.

In *Hormiscia* another modification of asexual reproduction prevails. Certain bodies called macrozoospores, or large zoospores, originate in the cylindrical cells of the filaments. These may be from one to four in a cell, and are of a thick, short pear-shape, furnished with four movable cilia, and possess also a coloured spot and a contractile vacuole. After becoming invested with a transparent bladder they make their exit through a slit, or opening, in the side wall of the mother-cell. After floating about for a short period, they come to rest, and fix themselves by the mouth-end, lose their cilia, and develop a new covering membrane. The fixed end soon exhibits a kind of root-like attachment, the free end acquires a club-shape, then divides by a cross division into two cells, each of which again subdivides, and so on, so that a young plant is speedily in active growth and develops into a counterpart of the parent from whence it sprung.

In *Coleochæte*, again, one form of reproduction is asexual. The zoospores which are produced in the early part of the year from the resting spores of the previous year give origin only to asexual plants, which
only form zoogonidia. After a series of asexual generations, variable in length, a sexual generation appears, and the method of reproduction is changed.

In *Hydrodictyon* there are two kinds of moving germ-cells; the larger are "macrogonidia," the smaller "microgonidia." The macrogonidia, more or less numerous, according to the size of the mother-cell, combine to form a new plant, which they do after a short trembling movement, lasting about half an hour; then they unite together into a miniature net within the confines of the mother-cell, but gradually become free by the dissolution of the cell-wall. The microgonidia, which are smaller and elongated, have four long cilia each, and when the mother-cell bursts they swarm out into the water, where they disport themselves actively for about three hours, then settle to rest, become green globules, vegetate a little while, and then die away without making any further progress.* A more succinct account of the macrogonidia represents them as formed in the protoplasmic stratum, occupying the outer portion of the interior of the *Hydrodictyon* cell. The first alteration in this, presaging their formation, is a disappearance of the starch granules, and a loss of the beautiful transparent green colour. Shortly after this, even before all traces of the starch-grains are gone, there appear in the protoplasm numerous bright spots placed at regular intervals; these are the centres of development, around

which the new bodies are to form. As the process goes on, the chlorophyl granules draw more and more closely around these points, and at the same time the mass becomes more and more opaque, dull, and yellowish brown in colour. This condensation continues until at last the little masses are resolved into dark hexagonal or polygonal plates, distinctly separated by light, sharply defined lines. In some the original bright central spot is still perceptible, but in others it is entirely obscured by the dark chlorophyl. The separation of these plates now becomes more and more positive, and they begin to become convex, then lenticular, and are at last converted into free, oval, or globular bodies. When these are fully formed they are said to exhibit a peculiar trembling motion, mutually crowding and pushing one another, compared by A. Braun to the restless, uneasy movement seen in a dense crowd of people in which no one is able to leave his place. Whilst the process just described has been going on, the outer cellulose wall of the Hydrodictyon cell has been undergoing changes, becoming thicker and softer and more and more capable of solution, and by the time the gonidia are formed it is enlarged and cracked, so that the room is afforded them to separate a little distance from one another within the parent-cell. Now the movements are said to become more active—a trembling jerking which has been compared to the ebullition of boiling water. There is, however, with this a very slight
change of space, and in a very short time the gonidia arrange themselves so as to form a little net within the parent-cell, a miniature in all important particulars of the adult *Hydrodictyon*. The primary cell-wall becomes more and more gelatinous, and soon undergoes solution, so that the new frond is set free in its native element.

It is uncertain what precise value or position should be assigned to the moving spores in *Spirogyra*, described by Pringsheim.* Meyen noticed that secondary, but not moving, cells were often formed inside the spores of *Spirogyra*, and he conjectured that there were likewise propagative cells. Pringsheim also found these secondary cells, in which the contents are frequently transformed into spores not directly germinating, in spores which had originated through copulation. They were always, however, motionless, and he was equally unsuccessful in observing a further development of these cells. But he also frequently found the contents of the filament cells, when no large spore had been previously formed in them, transformed into peculiar cells, which appear as the mother-cells of smaller moving cells, and the latter appear to stand in close relation to the development of the *Spirogyrae*. He says, "I frequently found in conjugated filaments that the contents of one or more pairs of conjugated cells were not transformed into the well-known large spore, but into a number

* *Annals of Natural History*, xi. (1853), p. 292.
of little cells of regular, definite, and unchangeable form. This regular occurrence led me to conjecture that these cells were more than mere pseudo-forms of decaying cell-contents. I first obtained an insight into these structures by observation of their production in the cells of the young *Spirogyra* which I had myself seen emerge from large spores. In the cells of these young *Spirogyra* the existing spiral bands are often broken up, and from their substance are formed, in a manner still unknown to me, little cells in which a membrane can be clearly detected surrounding green contents. I call these cells 'spore-mother-cells.' They soon increase in size, their membrane separating itself from the contents and expanding into a largish hollow vesicle. The contents at the same time acquire a yellowish or yellow-brown colour, and separate into a central denser, yellow-brown nucleus, and a finely granular mucilage, which surrounds the nucleus and does not entirely fill the space between it and the membrane. This finely granular mucilage then becomes balled together, in the space between the yellow nucleus and the surrounding membrane, into a single large corpuscle, exhibiting a sharply defined outline, and appearing as a transparent vesicle with finely granular contents. The new cell thus formed pushes the brown body out of its central position against the wall of the parent-cell or the 'spore-mother-cell.' The pressure of these two bodies causes the rupture of the membrane of the
'spore-mother-cell;’ the transparent cell emerges and moves about independently and freely in the filament cell in the manner of the zoospores.

"The expelled zoospores are small elliptical cells, and their aspect resembles that of the moving spores of *Achlyna prolifera* more than of any others. Their movement is much slower than that of other zoospores, and is further distinguished by the fact that in advancing they do not make a complete revolution round their longitudinal axis, but merely slight oscillations to the right and left. In moving about they traverse the cavity of the filament cells in all directions, mostly gliding onwards along the wall as if, as it were, seeking an orifice whereby to escape; but, notwithstanding that, I observed very many of these moving cells for long-continued periods. I never saw them emerge from the filament cells in which they had been produced, since no orifice was ever formed in the everywhere-closed filament cells. That these cells possess locomotion threads, or cilia, is certain. I could often detect them in vibration with the greatest clearness; but I remained in uncertainty as to the number or the vibrating threads. I think it most probable that they have one single thread at the anterior extremity; yet in certain cases it appeared as if they bore a crown of several threads.

"After wandering about unceasingly for several hours, they finally fix themselves by the point. All, however, that I have observed, after they had come
to rest, became decomposed without further organic development, and their contents, which as long as they were in motion were always coloured yellow, and never blue with iodine, became transformed into a number of very small irregular starch granules, coloured blue by iodine, around which could often be detected an enveloping coat, the membrane of the dead spore.

"The question now arising, how are we to interpret these moving structures, it appears to me that their mode of formation and the regularity of their appearance necessarily repel the idea that they are accidental, abnormal productions, without further value in the development of the plant. In my opinion the most direct and simplest assumption, in the present condition of science, is, that they are propagative cells of the *Spirogyra*, capable of development, and, if set free under favourable circumstances from the filament cell, during their motion they would reproduce the parent plant."

The production of these moving spores, or zoospores, within the true spore or in the vegetative cells, does not appear to be confined to *Spirogyra*, but extends also to *Ædogonium*, and may probably yet be recognized in many other genera of the filamentous fresh-water algae.

In *Chroolepus* the process of reproduction appears to be asexual, according to the present state of knowledge. "The apical cell of the threads has often a
INTRODUCTION TO FRESH-WATER ALGÆ.

Globose or pulvinate appendage, of a highly refractive nature, furnished with transverse wrinkles, and frequently also with a protuberance at the top. The whole cavity of the cells is filled with granular matter, mostly of a brownish-red colour, but it frequently happens that the inner granules only are brownish red, whilst the outer ones are green. The reddish-brown granules seem to be oil-drops. A great number of the threads terminate with a globose, much-thickened cell, which subsequently becomes the mother-cell of the zoospores. This mother-cell is rarely found in the middle of the threads. Occasionally, but still more rarely, the cell immediately under the mother-cell elongates itself sideways and upwards into a thread. The mother-cell of the zoospores, when it forms the terminal cell of the thread, bears a conical mass of gelatin, often of considerable size, which, however, is seldom on the crown of the cell, but usually at its side. In those mother-cells, in which the zoospores are about to escape, a division of the contents into small oval cells is clearly perceptible, and at the side, or near the top, the wall is extended into a short papilla. The contents emerge in the form of a well-defined vesicle, with the zoospores penetrating through the ruptured papilla; sometimes, however, no vesicle is formed. A few moments after emerging the vesicle bursts, doubtless by absorption of water, and the zoospores swim about in every direction. The remnants of the
vesicle are of a gelatinous nature. The escape of the zoospores was observed from nine in the morning until four in the afternoon, and seems to depend not upon the influence of light, but solely upon the effect of moistening with water. The zoospores are very small, about 3\(\frac{1}{2}\)\(\mu\) long. They are filled with reddish-brown granular matter, the apex alone being free and hyaline; there are two cilia, about three or four times as long as the spore, the apex being directed forwards. They rotate perpetually whilst swimming, their motion being so rapid as to prevent a clear view of them, except when stopped by some obstacle or when their motion is becoming retarded. The cell is surrounded by a clear, highly refractive border, looking like gelatin, but which may be only an optical appearance. After continuing in motion for about an hour the zoospores become sluggish, sink, become globose, elongate themselves, and shortly a division of the cell takes place by a transverse septum. Some reddish-brown granules usually remain behind in the empty mother-cell and in the remnant of the vesicle. Oftentimes some zoospores cannot emerge from the mother-cell, and then they sometimes germinate within it.”

A peculiar mode of asexual reproduction has been investigated by Wille,† with the unpleasant result


that it has added two new terms to the already overdone catalogue of technicalities proposed in crypto-gamia. Let us hope that *Akinetes* and *Aplanospores* will not survive a winter of disapproval. The reproductive process alluded to is not uncommon amongst filamentous algae, such as species of *Conferva*, etc. All the cases agree in the reproductive cells being immotile, not produced by any sexual process, and not resulting from swarm-cells which have come to rest. They are classed under two forms—(1) those produced without any special cell-formation, and (2) those produced after special cell-formation. Both kinds may germinate immediately after formation, or only after a period of rest.

The membranes of the filament become thicker and encrusted with iron and lime; as soon as the separate cells again begin to grow, the outer dead layer bursts, and the form arises which previously was known as a distinct genus under the name of *Psichohormium*. In *Cladophora fracta* single cells at the end of filaments often swell up in the autumn, and become thicker walled and fuller of protoplasm. These hibernate, filaments with thin-walled cells springing from them in the spring. The author's view is that these structures are formed whenever the conditions are unfavourable for the production of zoospores, or for sexual reproduction. Where they are abundantly produced, usually the formation of zoospores is rare. These reproductive cells have been termed “resting
cells," as well as the two names applied above, which we have no anxiety to repeat.

In the group of algae known as Nostochineæ, no sexual reproduction has been discovered. What are the real functions of the heterocysts is problematical. That certain special cells are capable of enlargement, and conversion into spores, which will germinate and produce new plants, has been admitted, but without any evidence of fecundation. The other process, and more usual one, is by the conversion of fragments of the thread, or trichome, into hormogones. The mucilage of the old plants is softened, and portions of the threads are detached and escape from the mucilage, whilst the heterocysts remain behind. These escaped fragments become endowed with motion, similar to that observed in Oscillaria. The cells of the hormogone increase by division, at right angles to the filament, so as to result in a double row of cells, which ultimately separate longitudinally, and become the centres of new plants.
CHAPTER VI.

SEXUAL REPRODUCTION.

The subject of sexual reproduction will come most naturally and effectually under three headings and aspects—general sexual reproduction, conjugation, and pairing of zoospores. It is hardly possible to accomplish this in a satisfactory manner without a certain amount of technicality, but an effort will be made to reduce rather than increase merely technical distinctions, which would only embarrass the reader, without corresponding practical advantage in the further pursuit of the study. Cienkowski’s researches into the history of *Cylindrocapsa* exhibited what may be regarded as a normal form of sexual reproduction. “This alga possesses antheridia and oogonia, representing the male and female element. The oogonium is a globular inflated joint, consisting of contents and wall. The first presents a protoplasmic gonosphere, coloured by chlorophyll, containing numerous starch granules; it presents at one point of the periphery very often a clear spot. The gonosphere is loosely enclosed by the several (3–6) concentric gelatinous
SEXUAL REPRODUCTION. 67

(as it were swollen or expanded) membranes. Such oogonia lie either several together, forming a moniliform chain, or they present themselves in the middle of a series of antheridia, or between unaltered vegetative joints, upon which, further on, may abut antheridia. *Cylindrocapsa* is thus monoeious. At both poles of the oogonium the coats are produced into a short cylindrical process; adjoining processes are mutually apposed. The size of the oogonia varies; it may reach \( \cdot042 \) mm., the gonosphere \( \cdot024 \) mm.

"The antheridia are discoid or sphæroidal little cells; like the oogonia possessing a multi-laminated coat, they may form a long series or little groups of pairs; they are often enveloped in twos or fours by numerous laminæ. The contents are clear reddish yellow. The male cells (like the vegetative) are formed by binary division of the mother joint, with the distinction that they cease to grow, remain smaller, and gradually assume the yellowish-red colour. Each antheridium develops by division of its contents two spermatozoids. At maturity they are ejected with a jerk; when free, they lie for a while motionless, enclosed in their gelatinous envelope. Presently they assume a tremulous motion, at last bursting the vesicle and swimming about. They are protoplasmic fusiform bodies of about \( \cdot015 \) mm. in length, contents sparing, yellowish red; at the anterior hyaline point are borne two flagella, below which are two minute pulsating vacuoles."
"Shortly after their exit they are to be found in the neighbourhood of the oogonia. The whole cavity of the oogonium becomes pushed out laterally, dissolving and leaving an opening at the apex of the expansion. The spermatozoids seem now to be no way aimless in their movements, their whole object being seemingly to effect a penetration; with great energy they drive against the wall, and retreat, and so persist for hours, until at last the movement ceases, and they shrink into formless little masses. The actual confluence of the spermatozoid with the gonosphere was not observed, but the conclusion drawn by the author seems to be legitimate.

"The next change consists in the appearance of a thick gelatinous stratum directly on the surface of the gonosphere, which soon hardens into a doubly contoured membrane. After some days the chlorophyll with the starch granules gradually disappear, becoming replaced by the reddish-yellow oily substance. In this way we obtain from the gonosphere an oospore surrounded by the mucous layers of the oogonium. The author could never see any further development; they lasted the whole autumn and winter without the slightest alteration.

"In some instances the gonospheres on having become enclosed by the gelatinous envelope began to germinate; they divided into two segments, each then becoming clothed by its own gelatinous envelope, and soon divisions followed just as in the ordinary vegeta-
tive joints. The author supposes that these still green gonospheres could not have been fertilized, and that only the latter, pass over into a state of rest."*

Similar in many respects to the reproductive process in *Cylindrocapsa* is that which is found in *Sphaeroplea*. The female element is represented by red globular spores surrounded by two hyaline membranes, the inner of which lies close upon the contents, whilst the outer is somewhat separated and elegantly creased, so that they have been called stellate; after a time, and subsequent to fecundation, they become resting spores, ultimately breaking up into zoospores. The male element is represented by active rod-like spermatozoids which originate from the differentiation of some of the cell-contents.

The full-grown cells exhibit in their contents most elegant structures. The constituents—colourless protoplasm, green chlorophyll, watery fluid, and starch granules—are distributed in a peculiar manner; the watery fluid forming large bubbles or vacuoles, which attain nearly to the diameter of the cell, and hence stand in rows like pearls, often in contact at their poles, and flattened there so as to form apparent septa. In the interval between the vacuoles is compressed the green plasma and starched granules, mixed with numerous smaller vacuoles. Under a low power, the whole appears like a regular alternation of narrow green and broad colourless rings. If the vacuoles are

smaller and the chlorophyll more abundant, the cell appears uniformly green, more intense only in the interval between the vacuoles.

Later on, the regular arrangement of green rings will disappear in particular cells, the vacuoles increase in number, so that the whole contents assume the appearance of a green froth, with the starch granules irregularly diffused through it. These are soon seen to become grouped in twos or threes, and largish masses of the green plasma become accumulated around them. After a certain time the middle line of the cell is occupied by a great number of green lumps at regular distances, the frothy matter being distributed between them. As the majority of the vacuoles gradually disappear, these lumps assume the form of green stars, remaining connected together by the green radiating filaments of plasma. Between each pair of these stellate masses a large vacuole is formed, which becomes flattened to level septa, so that the whole cell appears as if divided into chambers by a number of parallel plates. In each of these chambers follows an uninterrupted metamorphosis of the green mass—the mucilaginous filaments gradually retracted; the green substance sometimes contracting towards the right, sometimes to the left. In a short time the colourless plasma becomes so distributed around the chlorophyll that the septa of the chambers separate, and the whole contents are broken up into a large number of free globular masses sharply defined, composed chiefly of
SEXUAL REPRODUCTION.

colourless mucilage, and enclosed in their centre an irregularly diffused, most laterally situated heap of chlorophyll. These masses, which are the young spores, then pass through various stages. At first they are in contact, forming by their adjacent boundaries the plasmic septa, which are consequently double; the substance becoming somewhat contracted, the two layers of these septa separate, the spores thereby becoming isolated; the chlorophyll in the interior is constantly changing its mode of distribution. The colourless mucilaginous envelope at one time contracts strongly, so that free regular globules are produced; at another it expands again, so that they are flattened against their neighbours; or sometimes one becomes elongated laterally. Finally the nascent spores become rounded off into smooth spheres, which are larger than when mature, and not completely filled with chlorophyll. The colourless plasma is more elaborated and excreted, so that the spore is constantly becoming more condensed and diminished in size, and finally becomes a regular sphere, composed entirely of a green granular substance, enclosing a few starch granules, bounded externally by a smooth, clearly defined layer of plasma. There is no cellulose membrane, and the green structure is very soft and elastic.

This course of development does not take place in all the cells of a filament. During the same epoch totally different processes are being completed in other cells. Here the green rings between the colourless
vacuoles will gradually assume a peculiar colour, becoming reddish yellow, and the starch granules will have vanished. The orange-coloured substance is soon seen to acquire a peculiar organization. In it may be detected, progressively, a separation into granules, then into little streaks, and finally it becomes converted into myriads of short, confusedly crowded little rod-shaped bodies. After this the rings begin to dissolve. Suddenly one of the little rod-shaped bodies, embedded in the substance, acquires its liberty, and begins to move about in the cavity of the cell; more follow the example; the movement of these bodies becomes more and more rapid. In a few minutes the entire ring becomes decomposed into a countless number of actively moving corpuscles; then the rod-shaped bodies of a second and third ring enter into the movement, until finally the entire cell becomes filled with these corpuscles, which shoot about and circulate in all directions amongst each other.

The rod-shaped bodies now emerge through a hole in the wall of the mother-cell into the water. Their movements are at first very weak; they adhere firmly together, and oscillate in masses; but in a short time they acquire greater energy, and become scattered like dust, with infinite rapidity, through all parts of the water, so that within a few hours all the moving corpuscles will have left the parent-cell.

It is not rare to find in the cells, after the exit of
the rod-shaped corpuscles, other larger brownish globules, which often display a sluggish movement. These have been termed *pseudo-gonidia* by Braun, and are the remnants of the cell-contents which have not been converted into rod-shaped corpuscles, but have acquired a power of independent motion. Similar bodies are sometimes found in other cells mingled with the spores.

The rod-shaped bodies, above alluded to as swarming out of the cells, differ from the spermatozoids of the *Fucoidea* and others. They are elongated and rod-like, with the posterior extremity somewhat expanded, often spread out flat, and of a yellow colour; the other extremity runs out into a long, narrow, colourless beak, bearing at the end two long cilia. Their movement is characteristic. When the energy is weak, they oscillate; when the motion is more active, they rotate on their transverse axis, like a stick fastened in the centre. Sometimes the corpuscles rotate upon themselves without moving from one spot, like a cat around its tail; but they mostly dart off in cycloids, frequently advancing with jerks and springs; more rarely they screw themselves straight onwards. Cohn states most distinctly that he "succeeded in demonstrating their fecundating power, by direct observation, with an evidence such as can only be possessed by a fact of natural science; there can be no doubt that the active rod-shaped corpuscles are the spermatozoids of *Sphæroplea*, and therefore the
cells in which they are formed must be denominated the antheridial cells."

When the discharged spermatozooids have become dispersed through the water, they are soon seen to assemble around those cells of the filament the contents of which have been metamorphosed into spores. They dance about in the vicinity of those cells, attach themselves to the membrane, sometimes tearing away again, soon to return. After a while a spermatozooid approaches one of the little orifices, perforating the walls of the sporangial cells, where it fixes itself, and pushes the slender beak into the hole. The posterior extremity is often too broad to pass uninjured; then it screws itself forward with evident effort, the beak constantly working its way, compressing the elastic body; finally it succeeds in forcing its way through and entering into the cavity of the sporangial cell. In the mean time other spermatozooids have slipped in through various orifices; frequently three or four crowd at once into one orifice. The more slender corpuscles make their way, at the first attempt, in a remarkable manner, swimming in wide curves from the water, through the hole, without obstruction, into the cavity of the cell; after a time, as many as twenty spermatozooids circulating about in its interior, and swarming round the young spores. The spermatozooids rush from one spore to another, as if electrically attracted and repulsed, so rapidly that the eye can scarcely follow them; they often swarm from one
end of the sporangial cell to the other. Now and then the spores are thrown into slow rotation by the vibratile cilia of the spermatozoids; but this is only accidental, possibly only when the spores are in a very free position. Cohn has seen the spermatozoids moving about in the sporangial cell for more than two hours. Gradually their motion becomes more sluggish; they become adherent to the young spores in such a manner that one or two spermatozoids become fixed to each spore, cleaving firmly to it with the beak and cilia, so that their body stands perpendicularly upon the spore. In this position they oscillate backwards and forwards for some time longer. Finally they come quite to rest, and apply themselves with their whole length against the surface; their body is converted into a drop of mucilage and loses its form, finally melting away.

After a short time the impregnated spore becomes enveloped by a true cell-membrane; then a second is soon produced beneath the first. Ultimately the first-formed membrane is cast off by a kind of "moulting," and the second becomes the outer stellate coating, beneath which, again, a smooth coat is produced. The contents of the spore, originally of a uniform green, subsequently become opaque, and pass through olive-green and reddish-brown into a pure red.*

In most instances these fertilized spores pass into

* Cohn on *Sphærolea* in *Annals of Natural History*, xviii. (1856), p. 81.
INTRODUCTION TO FRESH-WATER ALGÆ.

a resting condition, in which they remain for some months, ultimately breaking up into zoospores; but under cultivation the process has been hastened, so that zoospores were produced within forty-eight hours. The remarkable fact that the spores of Sphaeroplea do not always give origin to one individual, but mostly to several swarming cells, and therefore to several plants, has not been explained. Cohn suggested whether it may not be connected with the action of one or more spermatozoids upon the nascent spore; but this, he says, must remain unanswered, the only analogy being afforded by the origin of several embryos in the ova of the Planariae.

Sexual reproduction in the genus Eudogonium is of a rather complex form. Some of the species are monœcious; that is to say, the male and female organs are present in the same plant. Other species are dicœcious, the male and female organs being found on different plants. In the latter group there are two modes of fructification, and in the former but one. In the monœcious species, the oogonium, or spore-cell, is inflated and more or less globose, enclosing a single spore of the same form. This oogonium, or spore-cell, is perforated by a pore, or splits all round and opens with a lid. The same thread which bears the oogonium has also, either above or below, as the case may be, shortened cells in the common filament, in which the male element, consisting of one or two active spermatozoids, are
produced. When these spermatozoids are fully mature, they escape from the cell in which they are generated, and fecundate the oospore through the pore or opening of the spore-cell, or oogonium, after which they disappear, and the oospore ripens into a perfect, fertile, resting spore.

In the dicëcious species, which are those in which the male and female elements are found on different plants, there are two modes of reproduction. In one series of species the male organs are dwarf, so that they might almost be termed antheridia. The oogonium, or spore-cell, and the spore are practically the same as in the monoëcious species. There are also shortened cells in some other part of the same thread, but instead of producing spermatozoids, they develop small active, ciliated bodies, which move about for a time, and then attach themselves either immediately upon, or in close proximity to, the oogonium, or spore-cell. When attached, they grow into the form of an inverted flask, being supported by a more or less elongated stem, and in this form they constitute the dwarf male plants. The cells at the apex of these little males contain the spermatozoids, or fertilizing elements. The upper cell opens by means of an operculum, or lid, to permit of the escape of the spermatozoids, which soon find their way into the oogonium, near which they are seated, and the fertilization of the spore takes place (Fig. 67).

In the second series of dicëcious species there are
male filaments, which in all respects resemble those of the sterile females, except that they are a little thinner. The female threads produce only oogonia, or spore-cells. The male threads have shortened cells in certain positions, which give origin to the spermatozoids, and these in due time escape and fertilize the oospores of the female plants.

So that in the first series the dwarf males are generated in certain privileged cells of the female plants, whilst in the second series the male and female plants are from the first distinct. In both cases the spermatozoids are discharged into the surrounding water, in which they float, endowed with ciliary movement, and ultimately find their way either through the pore, or the opening of the lid, of the spore-cell of the female plants, and fertilization is accomplished. It need not cause any surprise that, in earlier times, when so little was known of the processes of reproduction amongst the simplest of vegetable organisms, the movements of zoospores and spermatozoids, directed apparently in a definite direction, and for a special purpose, in a manner suggestive of instinct, should have been credited with the possession of animal life.

Sexual reproduction in Vaucheria bears some resemblance to that in Edogonium, but there is a special male organ developed in the former, directly, and in close contiguity to the sporangium or female organ. In this sense it reminds one of certain phenomena of sexual reproduction in some fungi, and is
SEXUAL REPRODUCTION.

sufficiently distinct from the reproductive process in *Cedogonium* to require detailed description, on the basis of the investigations of Pringsheim and others. In *Vaucheria* the male and female organs arise like short teat-like branches from the filament, and in close proximity to each other. It is usually the case that the projection which is to become the "hornlet," or male organ, is developed sooner than that in which the sporangium makes its appearance. The two papillae differ from the first so considerably in their dimensions that they can scarcely be confounded. The papilla which is to become the "hornlet" soon elongates into a short cylindrical branch, which at first rises perpendicularly from the filament, then curves downwards until it comes in contact with the tube or filament, often forming a second or a third curve, and, in this way, always represents a more or less stunted branch, which frequently exhibits several spiral turns. The papilla of the neighbouring sporangium usually begins to appear at the time when the hornlet is commencing its first turn; but the period at which it arises is very indeterminate, for it sometimes appears much earlier, whilst the hornlet is still perfectly straight; sometimes much later, after it has curved, so as to form two limbs of equal length.

The papilla destined to become the sporangium gradually enlarges into a considerable-sized lateral out-growth of the tube, far exceeding the hornlet in width, whilst in length it is barely equal to the
straight limb of the latter. This out-growth, which is afterwards symmetrical, ultimately throws out a beak-like prolongation on the side looking towards the hornlet, the rostrum or beak of the sporangium, whence the latter acquires its peculiar form, resembling that of a half-developed vegetable ovule. Up to this period the hornlet, as well as the sporangium, are not shut off from the tube by any septum; the cavity of the hornlet and that of the sporangium consequently remain uninterruptedly continuous with the parent-tube or filament, and are filled with similar contents. A number of chlorophyl granules in an albuminous plasma, and rounded oil globules, constitute a dense lining to the tube, the sporangium, and the hornlet. Between this and the cellulose membrane is the thin colourless skinlike layer.

At this stage a septum is suddenly formed at the base of the sporangium, which is henceforth an independent cell, completely separated from the parent-tube. Even before this septation there may be noticed in the rostrate elongation directed towards the hornlet, the gradual accumulation of a colourless fine granular substance, of the same nature as that with which the wall of the parent-tube and the sporangium is lined on the inner surface, which has already been termed the skinlike (or cutaneous) layer. This accumulation in the fore part of the rostrum is continued after the formation of the septum between the sporangium and the tube, and, in consequence of
its continued increase, the remaining contents of the sporangium are by degrees pushed back towards the base. Whilst these phenomena are being manifested in the sporangium, the hornlet also undergoes remarkable changes. In its apex, the contents, owing to the disappearance of the chlorophyl, have become almost colourless, more or less. Thus the point of the hornlet, like that of the sporangium, appears at this time to be filled with a colourless substance, which is not constituted by an accumulation of the cutaneous layer, but manifestly arises from a molecular change, associated with an alteration of form and colour, in the contents previously existing at the apex. So soon as the contents at the point of the hornlet have thus become colourless, they appear to be constituted of a very fine-grained granulose mucous substance. As soon as the transformation of the contents has taken place, the colourless apex of the hornlet is suddenly separated from the lower green portion by a septum, and is thus transformed into an independent cell, without communication with the parent-tube. The point at which the septum is formed is not very determinate, the portion cut off being sometimes larger, sometimes smaller.

After the formation of the septum in the hornlet, the colourless mucus in its apex gradually assumes a more determinate form, and at this time a large number of minute, perfectly colourless, rod-like bodies may be readily perceived crowded together irregularly,
and, as it were, embedded in the surrounding mucus. Close observation will disclose an indistinct movement, exhibited even thus early by some of the little rods, from which their destination may be anticipated.

This perfecting of the hornlet coincides with that stage of development of the sporangium at which the accumulation of the cutaneous layer in the anterior part of the rostrum has attained its greatest extent, and these conditions immediately precede the act of impregnation, which is effected in the following manner:—

The pressure within the sporangium, especially in the direction of the rostrum, becomes greater and greater in consequence of the continued increase of the cutaneous layer in the fore part, until ultimately the membrane is ruptured exactly at the point of the rostrum, and allows a portion of the cutaneous layer to escape. The extruded portion becomes detached, and assumes the character of a drop of mucus, which remains lying near the opening of the sporangium, and ultimately perishes. The accumulation of the cutaneous layer in the fore part of the rostrum, and the escape of a portion of it, are merely the mechanism by which the opening is produced in the sporangium destined for the admission of the spermatozoids. Immediately after the formation of this opening in the sporangium, and in remarkable coincidence with the escape of the cutaneous layer through the rostrum, the hornlet opens at the apex, and pours out its
SEXUAL REPRODUCTION.

contents. Innumerable excessively minute rod-like corpuscles, mostly isolated, escape at once through the orifice. Those already isolated exhibit an extraordinary rapid movement in all directions, and those still embedded in the mucus do not become detached until afterwards, when they follow the others with equal rapidity. The field of view is soon covered with mobile corpuscles. In great number they enter the neighbouring orifice of the sporangium, which they fill almost entirely, penetrating through the portion of the cutaneous layer remaining, which, though without any definite boundary, offers a solid resistance to their further penetration into the sporangium. The corpuscles continue thus to struggle forwards into the cutaneous layer for more than half an hour; bounding against its outer surface, they retreat, again push forwards, again retreat, and so on, in an uninterrupted succession of assaults and retreats.

After this commotion has lasted some time, an abrupt boundary line suddenly appears in the outer aspect of the cutaneous layer, the first indication of a tunic forming around the contents of the sporangium, which were before bare. From this moment the mobile corpuscles are separated from the cutaneous layer by a membrane which effectually prevents their further action upon the contents. They continue, it is true, to move to and fro, and this movement often lasts for hours together, but at last they perish in the
rostrum itself. Even after the lapse of several hours the dead corpuscles may be seen in the rostrum, lying on the front of the sporangium, until at last they are completely dissolved and all vestige disappears (Fig. 55).

The cutaneous layer surrounding the green contents of the sporangium becomes transformed, after impregnation, into the coat of the true spore, which, thus formed, represents a large cell occupying the whole of the sporangium, surrounded on all sides by the persistent tunic, which is open in front and prolonged into the rostrum.

In this condition the spore remains for some time longer without being thrown off from the parent tube on which it was produced, but the colour of its contents gradually becomes paler and paler. The spore is at last rendered quite colourless, and presents in interior only one or more largish dark-brown bodies. When it has lost its colour it is detached from the parent-tube, in consequence of the decay of the membrane of the sporangium enclosing it. After some time—say, three months—the spore suddenly resumes its green colour, and immediately thereupon grows into a young Vaucheria, exactly resembling the parent plant.*

The essential elements in all these details of reproductive phenomena are the active and passive, special

SEXUAL REPRODUCTION.

fecundative, and receptive organs, male and female developments, for the sexual reproduction and multiplication of the species. Further and more exact investigation will doubtless increase the number of examples, and probably demonstrate that the sexual is the general and normal method of reproduction in the majority, if not in all the species.

Those interesting algae, called Batrachosperms, which are the desire of all amateur microscopists and algologists, are reproduced sexually by the following process:

"The antheridia are small roundish cells, full of a colourless protoplasm, which is remarkable for the very numerous bright granules which it contains. They occur either scattered or in groups, and are placed upon the upper ends of peculiar ovate cells, also filled with a colourless protoplasm. Most frequently there is a single antheridium to the basal cell, sometimes two; the latter number appears never to be exceeded. When matured, the antheridia open, and allow their contents to escape in the form of roundish or flattened bodies, which never, as far as known, acquire cilia, and have, therefore, no power of spontaneous motion. These bodies, which are believed to be spermatozoids, are unprovided with anything like an external membrane, and are composed of protoplasm identical with that in the antheridium. While these changes are occurring, certain cells in other localities are being transformed into female organs, to which
the name of *Trichogonia* is applied. These are borne upon cells similar to those supporting the antheridia. At first they are not markedly different from the other cells, but soon undergo a very rapid growth. This is not, however, regular, and is not partaken of by a band of tissue about one-third way from the basal end, so that at last a long somewhat flask-shaped cell is produced, with a very marked contraction at the point indicated, separating it into two portions. The wall of this cell is thin, but very distinct, and the cavity is filled with a homogeneous or very sparsely granular protoplasm, which is continuous through the narrow neck-like portion. After a time there appear one or more large irregular vacuoles, with actively moving corpuscles in them, and at the same time the neck appears to be stopped with a slimy substance. Careful examination with reagents shows that this is cellulose, and that it does not completely block the passage way through the isthmus. At this time there appear lying upon the free end of the trichogonia globular or flattened bodies, without external membrane, corresponding in all respects with those already described as being produced in the antheridia. The end of the trichogonium generally enlarges at this period into a sort of roundish knob, and by-and-by the end wall between this and one of these globules becomes absorbed, so that there is a free communication between the two. Whilst this is going on, the globule acquires a thin delicate coat, and there appears
in it a vacuole similar to those pre-existing in the trichogonium.

"The first result of this impregnation of the trichogonium is the deposit of new cellulose, and the complete blocking up of the passage way through the isthmus or narrowed portion. Already, before the fecundation, the upper cells of the branches supporting the trichogonia have produced numerous branchlets, which, growing upwards, more or less completely cover that organ. After impregnation, the cells near to the trichogonium become much larger and broader, their vacuoles disappear, and are replaced by a dense granular dark greenish-brown protoplasm.

"These cells now show a great activity in the production of numerous branches in the usual way; but it is the upper two alone which, with the trichogonium that they support, are concerned in the formation of the fruit glomerules. These put out all over their surface an immense number of protrusions, which soon, in the ordinary way, become the parents of as many twigs or branchlets, which, growing and branching precisely as do the vegetative branches, soon become excessively crowded. The base of the trichogonium participates also in the production of branches, and at last a dense ball is formed of pseudo-parenchymatous tissue by the forced adhesion of the crowded twigs. The central cells of the glomerule thus formed are very large and bladder-like. The outer part of the ball is composed of innumerable radiating rows of small cells, the end
cell of each branch being roundish, so as to present a convex external face.

"At maturity these cells open and allow their contents to escape as round masses, which appear to have no membrane, but begin at once to grow and secrete cellulose. Their after-history has not been made out with absolute certainty, but they are believed to directly develop the new plant."*

In addition to ordinary asexual reproduction, Carter † has detailed his observations on the sexual reproduction in Eudorina, which differs but little from that which prevails in allied genera. He says—

"When the process of impregnation occurs, the division takes place at the second stage, that is, when the Eudorina consists of thirty-two cells of the largest kind, each of which is about the 1-1866th of an inch in diameter within its capsule, which is therefore a little larger. The process is as follows:—

"At a certain period, after the second stage has become fully developed, the contents of the four anterior cells respectively present lines of duplicative subdivision, which radiate from a point in the posterior part of the cell (in the subdivision of other cells the lines of fissiparation tend towards the centre of the cell). These lines, which ultimately divide the green contents of the cell into sixty-four portions,

† H. J. Carter on Eudorina, in Annals of Natural History, October, 1858.
where the division stops, entail a pyriform shape on the segments, from whose extremities a mass of cilia may be observed waving in the anterior part of the cell of the parent, while yet her own pair of cilia are in active motion, and her eye-spot still exists \textit{in situ} on one side of her progeny, thus showing that the latter may be almost fully formed before the parent perishes. At length, however, this takes place, and the progeny (spermatozoïds) separate from each other, and finding an exit, probably by rupture, through the effete parent-cell and her capsule, soon become dispersed throughout the space between the two large ovoid cells mentioned, where they thus freely come into contact with the capsules of the twenty-eight remaining or female cells.

"The form of the spermatozoid now varies at every instant from the activity of its movements and the almost semi-fluid state of its plasma. Its changes, however, are confined to elongation and contraction; hence it is sometimes linear-fusiform, or lunular, at others pyriform, short, or elongate. The centre of the body is tinged green, by the presence of a little chlorophyl, while the extremities are colourless; the anterior one bears a pair of cilia, and there is an eye-spot a little in front of the middle of the body, also probably a nucleus. It is about 1-2700th of an inch long and about one-fifth as broad.

"Once in the space mentioned, the spermatozoids soon find their way among the female cells, to the
capsules of which they apply themselves most vigorously and pertinaciously, flattening, elongating, and changing themselves into various forms as they glide over their surfaces, until they find a point of ingress, when they appear to slip in, and, coming in contact with the female cell, to sink into her substance as by amalgamation. This author explains that there was some difficulty in seeing the act of union, but of the act itself he entertained no doubts. *Eudorina* in this stage also may frequently be seen with all the four anterior cells absent, and only a few spermatozoids left, most of which are motionless, and adherent to the capsules, indicating that the rest have disappeared in the way mentioned. Lastly, many *Eudorinae* in this stage may be observed with not only the four anterior cells absent, but with hardly a spermatozoid left, indicating that the whole had passed into the female cells, or had become expended in the process of impregnation.

"What changes take place in the *Eudorina* after this he has not been able to discover. At the time the female cells appear to become more opaque, by the incorporation of the spermatozoids, and the crenulated state of the posterior part of the envelope in this stage seems also to indicate an approach to disintegration.

"While undergoing impregnation the female cells always contain from two to four nuclei, as if preparatory to the third stage of development into which
they are sometimes actually seen passing, with the spermatozoids present and scattered among them; but the effect of impregnation generally seems to arrest this stage, and thus save the species from that minute division which leads to destruction.
INTRODUCTION TO FRESH-WATER ALGÆ.

CHAPTER VII.

CONJUGATION.

Fertilization by conjugation is a phenomenon widely known and readily observed in fresh-water algæ. There is a large section in which it prevails, known as the Conjugatae, to which Desmids and Diatoms are affiliated. Both these latter are excluded, for manifest reasons, from this work, as they can be more profitably studied by themselves, whilst sufficient still remain to prove that fertilization by conjugation is one of the common modes prevalent in fresh-water algæ.

Conjugation in the Zygnemaceæ is the union of two cells, either of separate filaments or of the same filament, the result being the formation of a kind of spore, called, after its mode of development, a zygospore. The cells containing the male and female element cannot at present be distinguished from each other, although De Bary states that he has observed a constant difference between the fertile and sterile cells of Spirogyra. Usually, all the cells of one filament appear to be either giving or receiving cells, so that the male and female elements would seem to
be distinct; but this requires more certain confirmation, inasmuch as in such of the species of *Spirogyra* as exhibit lateral, as well as scalariform conjugation, all the cells in one filament cannot be of the same kind.

Not long since Mr. Bennett endeavoured,* but, as it seems to us, unsatisfactorily, to establish the fact of the existence of distinct sexual filaments in *Spirogyra*, which could be easily recognized when not in the act of conjugation. The chief points on which he relied to prove his case were—(1) The difference in the size of the cell, the so-called germ-cells being the largest; (2) that the portion of the conjugating canal contributed by the germ-cell is shorter and wider than that contributed by the sperm-cell; (3) that the protoplasmic contents of the cells always travel in one direction—that is, that in scalariform conjugation the contents of the cells of one thread invariably pass over into the cells of the other thread with which it is conjugating; and (4) some observations belonging to the *Mesocarpaceae*, which we think fit to regard, with Wittrock, as distinct from the *Zyg nemaceae*.

However plausible, at first sight, the contentions might seem to be, they were not novel, for similar ideas had already been propounded by preceding authors, and set aside, nor was this resuscitation permitted long to remain unchallenged. Mr. F. Bates made a very successful effort to show that the conten-

tions were untenable.* Firstly, by reference to the
well-known differences in the length and diameter of
the threads in the same species. "Moreover," he adds,
"it has to be admitted that conjugation must have
commenced before even a guess can be made as to
which is a male and which a female cell. Now, when
we consider the many curious changes which take
place in the form, etc., of cells at the time of conjuga-
tion, we must needs be careful how we draw conclu-
sions from them on which to base a theory of sexuality.
Again, one may find mixed in the same gathering, of
one and the same species, threads having the spore-
cells cylindrical and longer than the spores, or swollen
and more or less wider than the spores, or so ab-
 abbreviated that the spores are crowded together and
placed sideways, being longer than their cells. Con-
sidering all these things, then, how can we place any
value or reliance on conclusions based on an infini-
tesimal increase in the diameter of one cell over
another?" Having examined the conjugated cells of
the species operated upon by Mr. Bennett, where the
cells preserved their cylindrical form he did not find
any appreciable difference of diameter; as a rule the
two conjugated threads were equal, or might vary to
a slight extent on either side. Another argument
adduced was that lateral conjugation was common,
even in the same threads as those which in other

* "On Sexuality in the Zygnemaceae," by F. Bates, in Journal
parts conjugated in a scalariform manner. Already it had been admitted that the lateral conjugation which had been described as taking place between adjacent cells of the same filament, if correctly observed, would raise a difficulty, since "all idea of sexuality of the filaments must be abandoned in these cases." In passing, it may be remarked that in the fifteen British species of the genus *Spirogyra* figured in Cooke's "Fresh-Water Algae," the majority are represented with lateral as well as scalariform conjugation. Therefore, if true, the theory would only be partially applicable, and partially "all idea of sexuality must be abandoned."

"As to the second point, that the portion of the conjugating canal contributed by the so-considered germ-cell is shorter and wider than that contributed by the sperm-cell; the suture marking their point of union will consequently show nearest the spore-containing cell. This conclusion has evidently been arrived at from observations made at the early stage of conjugation, and before the commencement of the passage of the contents of the one cell into the other. At this stage it is true that the tubular protuberance put forth by the so-considered sperm-cell does, when it comes into contact with the opposing protuberance, force slightly inward the opposing face; but this I take to be transitory, for afterwards there is doubtless resorption of the opposing membranes, with fusion of the tubular walls, so that a perfectly open channel of
communication is formed. When this is effected, and not till then, does any passage of the contents of the one cell to the other begin to take place. Then also it will be seen that the shortening and widening of the so-considered germ-tube was only due to the temporary pressure exercised upon it by the sperm-tube, for, when all is completed, the suture resulting from the fusion of the two portions will be found, as a rule, in the middle; although, as might reasonably be expected, it is sometimes met with nearer the one cell, and at others nearer to the other."

As to the third point, that the protoplasmic contents of the cells in conjugating always travel in one direction, Mr. Bates writes, "It is doubtless the rule that in scalariform conjugation, the one thread parts with, and the other receives the contents of the cells; but this fact is so overborne by others as to be deprived of all its significance as a test for sexuality. In several species I have found both scalariform and lateral conjugation; whilst it is also a fact that both forms of conjugation may be going on together in different parts of the same threads. In my mind this settles the question; for it must not be forgotten that Mr. Bennett abandons all idea of sexuality in threads conjugating laterally; and yet, really, this form of conjugation is nearly as common as the scalariform. It is unnecessary to continue the observations on the fourth point at issue, as it refers wholly to the Mesocarpaceæ, which we prefer to hold distinct.
Enough has now been said of the sexuality of the threads in *Zygnemaceae*, for the observations coincide with our own experiences and opinions, albeit we are not prepared to affirm dogmatically that such a thing is impossible, but that those who have asserted and affirmed sexuality have not yet proved their case, or invested it with plausibility.

Returning to the original test of conjugation, the following remarks may serve to illustrate the process:

"The first perceptible change in a cell about to produce a resting-spore appears to be a loosening of the primordial utricle from the outer wall, and a contraction of it upon the cell-contents, which thus are crowded together and more or less deformed. Simultaneously with this, or a little after or before it, the side wall of the cell is ruptured, and a little pullulation or process is pushed out, which directly coats itself with cellulose and rapidly enlarges to a considerable diameter, at the same time growing in length until it meets a similar process pushing out from an opposing cell, or has attained as great a length as its laws of development will allow. When two processes meet they become fused together, the end walls are ruptured, and the contents of one cell passing over are received within those of the other, or else the contents of both cells meet within the connecting tube, and there fuse together. This is the more common mode of conjugation, in which two cells of distinct filaments, become joined together by a con-
necting tube. It is evident that, if the filaments are fertile to their fullest extent, there will be as many of these connecting tubes as there are pairs of cells in the filaments, and a ladder-like body will be formed, the original filaments corresponding to the side pieces, the connecting tubes to the rounds. Hence this method of conjugation has received the name of scalariform (Fig. 48).

"In the so-called lateral conjugation, instead of cells of different filaments joining, adjacent cells of one filament unite together to complete the process. The union of the two cells appears to take place in several ways. In accordance with one plan, connecting tubes, pushed out from near the ends of the cells, grow for a short distance nearly at right angles to the long axis of the filaments, and then bend at a right angle to themselves, so as to run parallel to the filament cells. The ends of these processes are, of course, opposed to one another, and, coming in contact, fuse together so as to form a continuous tube for the passage of the endochrome. Another method by which neighbouring cells are sometimes connected is by the formation of coadjacent pouch-like enlargements of the opposing ends, and a subsequent fusion of these newly formed enlargements by the absorption of the end wall between them (Fig. 45c).

"There is still another method of conjugation, the so-called genuflexuous, in which, instead of a connecting tube being formed as the medium of union, two cells
of opposing filaments become sharply bent backwards, so that their central portions are strongly thrust forward as obtuse points, which, coming in contact, adhere, and allow of a passage-way between the cells being made by the absorption of their cohering walls." * 

This latter method prevails in the genus *Sirogonium*, of which there is one British species.

These three methods of conjugation, the scalariform, the lateral, and the genuflexuous, are found in the *Zygmenæ*. The two first may not only occur in the same species, but on the same individual thread; the latter is excluded from the genus and species in which the former prevails, and is confined solely, to the exclusion of the other forms, to that little genus of which it is characteristic, if we except the modifications it assumes in the *Mesocarpeæ*, hereafter noticed.

What are the conditions which influence the operations of scalariform and lateral conjugation respectively does not seem to have been ascertained. We know that one portion of an individual thread may conjugate with the similar portion of a neighbouring thread, in a scalariform manner, and that the remaining portion of the same thread may diverge from its neighbour, and develop lateral conjugation; but wherefore should it do so whilst an available neighbour thread is not only in close proximity, but really attached to it, by connective processes, at a short distance? This is the enigma to which, as yet, there

is no satisfactory clue. The only hypothesis suggested is that the cells, before evidence of conjugation, are really sexual; that a series of male cells, following each other uninterruptedly, must conjugate with a neighbouring filament of female cells, to the extent of the uninterrupted series; that beyond this the male and female cells alternate, and therefore, instead of seeking to ally themselves with a neighbouring thread, the proximate cells conjugate laterally. Whatever the explanation may be, it may be assumed that it is not a method of haphazard. The portion of a fertile thread which declines to conjugate in a scalariform manner, but at once conjugates laterally, will hardly do so because there is no suitable thread in proximity, but rather from some innate reason which prohibits scalariform conjugation. It may be that this reason will be found in the fact that male and female elements were already provided for in alternate cells. Evidence has not yet been adduced of the possibility of distinguishing active from passive, male from female, cells until the act of conjugation is accomplished, and the movements of the plasma give indication of the fecundating cell.

Conjugation in the *Mesocarpæae* differs somewhat from that of the *Zygnemaceae*, which has led to their recognition as separate families. The process may be summarized on the basis of the exposition made by Professor Wittrock in his memoir on this subject.*

CONJUGATION.

Two cells grow together in the ordinary manner by the projection of conjugating outgrowths, and absorption of the double cell wall at the point where the conjugating cells coincide. By this means a cross-shaped or H-shaped double cell is formed, in which at first no other change is observed than that the canal of conjugation is somewhat widened, and the green contents of the double cell move into the conjugating canal, and those parts of the double cell which are nearest to it. This cross-shaped cell, which is formed by the conjugation, is regarded by De Bary as the zygospore, but it exists only for a short time as such. The movement of the chlorophyll-like bodies into the connecting canal having been accomplished, the zygospore is divided by two or four septa into three or five cells, of which the central one has been termed a hypnospore, or "resting-spore," whilst the two or four lateral cells are sterile, and ultimately die. Thus the Mesocarpaceae, according to De Bary, have spores of two kinds—the zygospores, which are formed simply by the growing together of the two opposing cells, and do not rest; and the hypnospores, which are formed by the partition of the zygospores, and which rest for a time before germinating. On the contrary, the Zygnumeae (and the Desmids) have spores of only one kind, which are typical zygospores, in the formation of which a fusion and contraction of the entire protoplasm of the conjugated cells takes place, and which
become "resting-spores" without a preceding partition. Wittrock, in assenting to this, observes that the resting spores of the *Mesocarpaceae* are not analogous to the zygospores of the *Zygnesia*, and, indeed, that they are not zygospores at all; the resting spores of the *Mesocarpaceae* being formed by partition, and not by an immediate fusion of the contents of conjugating cells, as the case ought to be with zygospores.

Pringsheim, in referring to the same subject, describes the act of conjugation as consisting of two stages. The first, which is introductory, consists in the two cells which participate in the conjugation growing together by the conjugation outgrowths, and the septa between the conjugating cells being absorbed. This part of the process he calls *copulation*. The second stage consists in an intimate fusion taking place of the contents of the conjugating cells. This fusion is effected by the moving of the green parts of the protoplasm into, or into the neighbourhood of, the widened connective canal. This stage he calls the *connubium*. The conjugation having taken place in this manner, its effect appears in the three-parting or five-parting of the cross-shaped or H-shaped cell formed by the copulation. Of the cells formed by this partition, the central one is fertile, and the two or four lateral ones sterile. The result is consequently not one cell, but several cells, and not cells of one kind, but of two, namely, one propagative cell or spore, and around it two or four cells incapable of
germination. His conclusion is that the result is a sporocarp. Although it remains in a very low state of development, it yet possesses the constituent parts of a sporocarp. It has a nucleus and a pericarp, the nucleus being the central spore-cell, and the pericarp is represented by the two or four lateral sterile cells* (Figs. 51, 52).

At one time it was thought that a method of conjugation similar in principle to the lateral method was to be found in *Edogonium and Bulbochæte. Both Decaisne and Hassall had observed that, in these two genera, the cell which immediately precedes the swollen mother-cell of the spore, or oogonium as it is called, had little or no green contents. Hassall thought that from this fact it might be deduced that the contents of the lower cell had passed into the upper, in a similar manner to the lateral process of spore-formation in *Spirogyra, with this distinction, that the contents of one cell did not make their way into the next cell through the medium of a lateral connecting canal, but probably through an opening in the partition or septum dividing the two cells. To this hypothesis objection was taken, that it is not unusual to find both the lower and the upper neighbour-cell with unchanged green contents; also that sometimes two, three, or four cells containing spores may be seen following each other in immediate succession. Braun says, "If there were only two, it

* See Pringsheim's "Jahrbucher," xi. 1877.
might still be asserted that one had attracted the contents of the cell next below it, the other the contents of the cell next above it, in order to form the spore out of coupled contents; but, when three or four sporiferous cells follow in succession, such a coupling is no longer conceivable."* It must be remembered that this theory of pseudo-conjugation in *Edogonium* had its origin at a time when the real method of sexual reproduction in that genus was either unknown, or but imperfectly understood.

* Braun on Rejuvenescence (Ray Society), p. 301.
CHAPTER VIII.

PAIRING OF ZOOSPORES.

It has generally been assumed, in species of fresh-water algae where the only known method of reproduction is by means of zoospores, that, in consequence, in all such cases the process is asexual. Something more than a doubt was cast upon this inference by the researches of Pringsheim, who has shown that, in some cases at least, these zoospores being of two kinds, and presumably of two sexes, a process of copulation takes place, and, as a result, one kind of zoospore, after contact, passes into a state of immobility, becoming a kind of resting spore; and that these resting spores, produced by the so-called microgonidia, reproduce the mother-plant. "If it be not assumed," he says, "that all the plants without resting spores are asexual, it must follow either that their resting spores remain to be discovered (which is improbable), or that in the Zoosporeae, and in their already known organs, the sexual act takes place in a special manner not yet discriminated. The existence of two kinds of zoospores in the same plant seemed to afford a clue to the
INTRODUCTION TO FRESH-WATER ALGÆ.

discovery of this unknown sexual act.” What has been called by Pringsheim the “pairing of zoosporæ” seemed to him a modification of the sexual act, forming a link between the known forms of reproduction, and showing that the different sexual products are a series of variations, passing into one another, of one and the same form; the essential difference between this and other forms of reproduction being in the appearance of motile “brood-spheres,” which are externally just like the zoosporæ.

Something very similar to this was known to take place in some species of fresh-water algæ, between the active gonidia or zoosporæ. For instance, in the well-known Botrydium, certain zoosporæ conjugate in twos, sometimes several together. They come into contact by their ciliated ends, then touch laterally, and fusion takes place, when they present a cordate figure with a central colourless vacuole (Fig. 54). If these zoosporæ be isolated before conjugation, they ultimately break up, without presenting any products capable of germination.

Pringsheim* illustrates his views principally by reference to Pandorina morum. He says that asexual reproduction takes place in Pandorina, as in other multicellular Volvocineæ, by the formation of a perfect young plant in each cell of the mother-plant. By the gradual dissolution of the general envelope, and

PAIRING OF ZOOSPORES.

of the special membrane of the mother-cells, the young plants become free, and escape. In sexual reproductions, as in the asexual, the membrane of the old plant swells, and sixteen young plants are formed. The young plants, however, are (at least in part) not neuter, but sexual, and either male or female. Whether the mother-plant is monœcious or dioecious is difficult to determine, because the male and female plants are externally alike, and can hardly be distinguished with certainty during copulation. There is no striking difference in structure between the sexual and asexual plants, although, amongst the former, plants with less than sixteen cells, especially with eight cells, are oftener produced. Moreover, the dissolution of the membrane of the mother-cell proceeds more slowly than in the case of neuter plants, one result of which is that the young asexual plants vary much in the extent of their growth, and continue united in groups of different sizes for a long time after their formation, according as a greater or less number of them have happened to become free from the gelatinous mass in which they were embedded.

As the individual groups are at first motionless, and the mother-plant loses its cilia during the formation of the young ones, the entire group is at first entirely quiescent. But afterwards the young sexual plants, like the neuter ones, produce upon each of their cells two cilia, which commence their motion as soon as the enveloping mucus admits of it, and thus ultimately
the entire group assumes a state of active rotation. During the rotation of the groups the same process of expansion and dissolution takes place in the membrane of the sexual plants as occurred in the mother-plant; but the contents of the cells of the sexual plants do not undergo division, but combine to form a single zoospore, which becomes free by the rapid dissolution of the membranes. In their general structure these zoospores differ in no way from other zoospores. At their colourless apex they exhibit, like other zoospores, a red body placed on one side of the apex, and two long vibrating cilia, by which they move in the manner common to zoospores. The individual zoospores exhibit no marked differences, except that they vary in size within tolerably wide limits, but not in a manner to indicate the existence of two different sorts.

Amongst the groups of isolated zoospores of different sizes some are at last seen to approach one another in pairs. They come into contact at their anterior hyaline apex, coalesce with one another, and assume a shape resembling a figure of 8. The constriction which marks their original separation disappears by degrees; and the paired zoospores form at last a single large green globe, showing at the circumference no trace of their original separation. It may be seen, however, that the globe is larger than the individual neighbouring zoospores, that it has a strikingly enlarged colourless mouth-spot, with two red bodies on the right and left, and that it is furnished with four vibrating cilia.
PAIRING OF ZOOSPORES.

originating in pairs near the two red spots. The four cilia, however, soon become motionless, and together with the red spots disappear.

This act of conjugation occupies some minutes from the first contact of the zoospores to the formation of the green globe. The latter becomes the zoospore, which, after growing slightly larger, and assuming a red colour, germinates after a long period of rest, and brings forth a new Pandora. There is hardly any appreciable difference, except in size, between the male and female zoospores. Most frequently a small zoospore pairs with a larger one; but two of equal size often unite. Probably both the females and the males vary much in size, the former more so than the latter.

With regard to the entire plants from which the zoospores are produced, there is little doubt that those of the largest size are females; but the sex of the smaller and middle-sized ones cannot be determined with any certainty. The germination of the oospore is like that of other Volvocineae, especially resembling in its early stage the germination of the resting spores produced by the microgonidia of Hydrodictyon utriculatum. The oospore bursts, and produces a single large zoospore (in rare cases two or even three), which divides into sixteen cells, and becomes a young Pandora.

Thuret has shown that there is such a phenomenon as the "pairing of zoospores" to be observed in
INTRODUCTION TO FRESH-WATER ALGÆ.

Monostroma bullosum (or, as sometimes called, Tetraspora bullosa).

In Hydrodictyon, which possesses zoospores of two kinds, pairing has also been observed. "In certain cells are formed somewhat larger and less numerous gonidia (according to the size of the mother-cell, from seventy thousand to twenty thousand), in other cells of the same net somewhat smaller and more numerous gonidia (from thirty to one hundred thousand). Only the macrogonidia form a new net, which they do after a short tremulous movement, lasting about half an hour, without leaving the mother-cell, by uniting into a daughter-net, which is gradually set free by the dissolution of the coat of the mother-cell. The microgonidia, on the other hand, distinguished not only by their smaller size, but by a longer shape and four long cilia, swarm out from the bursting of the mother-cells, move about very actively, often for the space of three hours, and, after coming to rest, become green Protococcus-like globules, which vegetate for some time, and at length die away." Thus far was known to Alexander Braun, with something of a suspicion that somewhat more had to be discovered, which something is now interpreted by "pairing of the zoospores."

It is impossible to predict to what extent this pairing prevails in such species as possess two kinds of zoospores, probably in all of them, although at present it has practically been demonstrated only in
PAIRING OF ZOOSPORES.

a few; *Chroolepus* being one of the genera in which it is known to take place.

The polymorphous reproduction in *Hormiscia* includes "pairing" as one of its phases. Microzoospores are produced, from eight to thirty-two in each cell. These have two cilia, and, after swarming for a time, conjugate laterally in pairs, forming a zygospore, which attaches itself by the ciliated end. It grows slowly and finally breaks up, by simultaneous division of the contents, into from two to fourteen swarm-spores, which constitute the beginning of a new sexual generation. If any of the microzoospores remain behind in the mother-cell, they are able, without pairing, to germinate, and grow into independent plants, which may be seen, singly or in groups, projecting from the mother-cells.

That remarkable little stipitate *Miscococcus*, not unfrequently found parasitic on *Confervae*, has of late been added to this list by Professor Borzi. In addition to the ordinary branched, or treelike form, he describes a palmelloid form, spreading as a thin layer over the surface of water-plants, and dividing in two directions only. The cells in this form at length give birth to zoospores; sometimes one, sometimes two to four from each cell. On germinating they originate palmelloid colonies. The cells of the dendroidal colonies also give birth to zoospores, either one or two from each cell. These are microzoospores, as distinguished from the macrozoospores produced by the palmelloid
colonies. Under certain conditions the microzoospores conjugate, or pair, and the resulting spore has at first two cilia.*

Another proven example is *Stephanosphaera plurivialis*. The vegetative primordial cells, or macrogonidia, when about to divide, which is usually in the afternoon, retract all their protoplasmic threads, by which they were attached to the enveloping membrane, round themselves off, and then divide into microgonidia. Usually all the cells of a vegetative family become transformed into microgonidia at the same time. These microgonidia unite in the ordinary way by “pairing;” their anterior ends coalescing in the production of isospores, which are scarcely larger than the original microgonidia. Those which do not conjugate have been found in all cases to perish. The resting cells are always the result of the pairing of the microgonidia.†

* “Malpighia” (1888), ii. p. 133.
† Cohn’s “Beiträge” (1884), p. 51.
CHAPTER IX.

ALTERNATION OF GENERATIONS.

"Alternation of generations," as applied zoologically, differs materially from metamorphosis, although they are sometimes confounded as though they were convertible terms. The fundamental idea is that of an organism “producing an offspring, which at no time resembles its parent, but which, on the other hand, itself brings forth a progeny which returns, in its form and nature, to the parent animal, so that the material organism does not meet with its resemblance in its own brood, but in the descendants of the second, third, or fourth degree or generation, and this always takes place in the different animals which exhibit the phenomenon in a determinate generation, or with the intervention of a determinate number of generations.” *

The characteristic difference between this and a simple metamorphosis is that each generation completes its career in the same form as it commenced, so that each starts from an ovum, and the cycle is not the career of a single individual, but of a consecutive series of

individuals, which revert to the original form after one, two, or more intermediate and differing generations. Not only does this phenomenon take place amongst animals, but its analogy is to be found amongst plants, and amongst the fresh-water algae instances are to be met with in which something of the nature of alternation of generations occurs. It may perhaps be objected that these generations are not so distinct and pronounced as in the animal world, but still sufficiently so to justify the application of the same term to the phenomena of alternation.

Recent researches* into the life-history of Botrydium have furnished the following indications of a cycle of generations in that interesting little plant:—

"If a plant be placed in water, its contents become modified at the latter part of the day, or at night, into zoospores. Ultimately the wall swells, then bursts somewhere at the top, and the zoospores resulting from the division of the wall stratum escape. If the plant be only moistened, the zoospores do not swarm out, but come to rest within the collapsed wall. Such were known to previous observers as 'germ-cells' or 'gonidia.' The zoospores are elongated egg-shaped, with a single thread or flagellum, and two to four chlorophyl granules. Having swarmed out, they soon come to rest, lose the flagellum, become surrounded by

* Rostafinski and Woronin, "Ueber Botrydium granulatum" (1887); Cooke, "British Fresh-Water Algæ," p. 112.
a membrane, increase in size, and germinate on damp earth, in which stage they represent *Protococcus botryoides*.

"The large ordinary zoosporangia are also otherwise modified. If one is allowed to dry, its membrane collapses, loses colour, and soon becomes empty. The protoplasmic contents pass down to the branches of the root. Here they break up into numerous eells, sometimes two or three side by side, but chiefly in a continuous chain; each eell furnished with a separate membrane. These are capable of three forms of development. (1) If removed from the soil and placed in water, the eell becomes a subterranean zoosporangium. The formation of the zoosporangium is independent of light, at any hour of the day or night. The zoosporangium are similar to those above described, and germinate in the same manner. (2) If a chain of these root-eells be laid on moist earth, each protrudes a hyaline process, which enters the soil, the opposite end being elevated, and thus each root-eell becomes a vegetative plant. (3) If the root-eells are not removed, and kept equably moist, they also germinate in the earth, become inflated, put forth a root process, the wall of which becomes very much thickened on the inner side below the inflated upper portion. By intercellular growth of the root portion, the upper part becomes raised aloft, so that the apex is carried above the surface of the soil. These products of modified root-eells are named 'resting sporangia' (*hypnospo-
ranges), and are equivalent to the so-called *Botrydium Wallrothii*. When dried, the resting sporangia retain their power of germination during the whole year, and, when placed in water, form zoospores at any hour of the day or night, germinating and forming young plants as above.

"The zoospores germinate on a moist substratum. On earth or sand they thrive badly, but better on clayey or muddy soil. In water they never germinate, but come to rest, are surrounded by a double membrane, and lie dormant for months. If these be transferred upon a clayey soil, they commence to form a vegetative plant. If the zoospores be sparingly distributed over the soil, and the whole kept equally moist, the vegetative plants become ordinary zoosporanges. The plants are sometimes modified into 'resting sporanges' (*hypnosporangia*).

"Thus, vegetative plants can be increased by cell-division directly from zoospores, become ordinary zoosporanges, with such consequences as root-cells, etc., or they may be directly modified into 'resting sporanges.' But there is another way in which existence may be carried on. If exposed to drought, the following phenomena occur:—The wall collapses more or less, and the protoplasmic contents break up into a number of cells, each surrounded by a delicate membrane, its contents homogeneous, at first green, then passing into red. These are the spores, and have been known by such names as *Protococcus coccoma, Protococcus*
ALTERNATION OF GENERATIONS. 117

*palustris*, and *Protococcus botryoides*. These spores become changed in water to zoosporangia, their contents giving rise to zoospores in the manner already described. If the spores be still green, their zoospores will have a distinct fusiform figure, with two cilia at the end. They consist of slightly coloured protoplasm. These zoospores conjugate in twos, sometimes several together. They come in contact by their ciliated ends, then come to touch laterally by the uncoloured portions, when the fusion of the conjugating zoospores takes place, immediately after which they present a cordate figure, and in the middle a colourless vacuole. Finally the spore (*isospore*) thus originating becomes globular, the vacuole occupying the centre. If the zoospores be isolated before conjugation they will in the end break up, without presenting any products capable of germination.”

The zoospores originating from red spores have a different figure, their posterior end being rounded, but they have otherwise the same structure, and behave in the same manner as the others. The red spores maintain their germinative power for years, but after two years their zoospores are languid, and offer a parthenogenesis of a peculiar kind. The red spores, if kept moist only, become nothing altered after weeks, whilst the green, under these circumstances, may directly germinate into vegetative plants.

“The isospores (resulting from conjugation) are at first globular, and capable of immediate germination.
They also present resting stages, the original form becoming modified. Soon after conjugation these are flattened, with irregular lateral boundaries, which become on the following day hexagonal. The membrane becomes thickened and presents tuberculations at the margin, but no secondary membrane is formed. Brought upon damp earth, they soon become globular, and otherwise behave as ordinary isospores.

"In order to distinguish that which appertains to the cycle of alternation of generations from the rest, the simple method is to start from the fertilized germ, and see what are the modifications which are essential in order to arrive again at the same reproductive process. In this case we have the isospore; it germinates, produces the vegetative plant, which needs neither to divide, nor produce a sexual zoospore, nor to become an ordinary zoosporang— it can directly produce spores. These close the first generation. The second oospore generation occurs in the germination of these spores in the form of sexual zoospores, which directly lead to the formation of the isospore—the limits of two generations. All the rest are but phenomena of adaptation.

"Thus in nature the vegetative plants, in spring, almost all become zoosporangia, and spread the growth over considerable areas. Zoospores which fall into the water are not lost; they acquire a double membrane, and lie dormant until they chance mechanically to arrive on moist soil. If drought sets in, the plasma
ALTERNATION OF GENERATIONS. 119

retreats to the roots; if the earth be some time a little moist, the root-cells become 'resting spores' (*hypnospores*), awaiting the rain in order to develop multitudes of zoospores; but if the earth becomes rapidly dried, the root-cells remain unaltered, until a moistening excites the formation of the zoospores. A great many of the root-cells can manifestly accidentally reach the surface of the soil, and thus, according to the state of the moisture of the earth or air, sometimes germinate, sometimes become zoospores." All this is in the spring. The hotter months favour the formation of spores, but at that time only the vegetative plants are mostly to be found, either undergoing cell-division or spore-formation. They can also furnish uniciliated zoospores, without becoming modified into ordinary zoosporanges.

Formation of the ordinary zoospores may be accomplished in a fourfold way: (1) From the vegetative plant; (2) from the ordinary zoosporange; (3) from the root-cell; (4) from the resting sporangium (*hypnosporangium*).

Further modes of increase are—(5) By cell-division; (6) the formation of spores; and (7) the formation of zoospores.

This plant possesses also fivefold resting stages: (1) Of the asexual zoospores laid in water—for months; (2) of the root-cells—the year throughout in which they originated; (3) of the hypnosporangines—the year throughout in which they originated; (4) of the spores
—for years; (5) of the isospores—at least over the year in which they originated.

Much of the foregoing phenomena might be eliminated and transferred to polymorphism, some relegated to ordinary asexual reproduction, and some bearing the impress of sexual conjugation, but on the whole the history is so complex that the narrative is better retained here in its entirety.

From this we pass to another organism which Professor Cohn made the object of careful and special investigation, and now called Chlamydococcus, but at that period Protococcus pluvialis; his brief summary of results being—(1) "That Protococcus pluvialis is a unicellular alga, a simple cell, or at least the individual represents an organism which exhibits the conditions of a simple cell; each multiplication of the cell reproduces the species, and is at the same time an act of propagation; each dissolution of the parent-cell into secondary ones constitutes a new generation; each secondary cell is an independent individual of the same species. (2) It is a plant subject to an 'alternation of generations;' that is to say, the complete idea of the species is not exhibited in it until after a series of generations. The forms of development which can be possibly comprehended in the idea of the species, do not in reality make themselves apparent until a series of independent successive generations has been gone through. (3) The individuals of each such generation are capable of propagating
themselves in new generations. The individuals of the second generation are among themselves, speaking generally, of equal value; as respects the individuals of the parent generation, they are sometimes of equal value with them, sometimes not. (4) If the secondary cells are not of equal value to their parent-cells, a series of successive generations must precede the last generation, the individuals of which are, again, equivalent to the first mother-cell. The number of these generations does not appear to be determinate.

"Let us assume that a parent-cell has produced a number of secondary cells, which are of unequal value to their parent. The individuals of this second generation propagate a third generation equivalent to their parent-cell, or not equivalent. In the first case there may be also a fourth generation, a fifth, and more, which are all equal among themselves, and to their parents, but not equal to the parent-cell of the first generation, until at last a generation is produced which is not equivalent to its own parent. Now this is either equivalent to the first generation, and the cycle closes with it, or it is still not equivalent to it. In that case, it either propagates again a number of equivalent generations, or non-equivalent, until at last one appears which is equivalent to the first generation, and thus the cycle closes." *

This is the only place in which we can quote the

* Professor F. Cohn on *Protoococcus nivalis* (Ray Society), p. 541.
fuller observations of Cohn on the life-history of this remarkable organism.

"Normally fully developed cells of this multiform creature," he says, "sometimes like a plant, sometimes like an animal, present the appearance of globules from \(0.02\) to \(0.4\) mm. diam., with a thick, tough cell-membrane, and granular-punctate, opaque contents, sometimes of a brown, sometimes (at other periods, or in other localities) bright red colour. In the mass of the dark contents lie hidden several other structures, which at this period are completely concealed, namely, 4–6 starch globules of \(0.0033\) or at most \(0.005\) mm. in diameter, in which, as in those of *Hydrodictyon*, a nucleus and an envelope may be distinguished, acquiring a violet colour with iodine, the nucleus becoming rather redder. Sulphuric acid causes a considerable swelling up of the coat. There also appears to exist in the centre of the cell a large, very delicate nuclear vesicle, which, however, is so covered up by the rest of the cell-contents, that it can only be very indistinctly perceived, and cannot even be clearly displayed when the contents are squeezed out. When these resting globular cells are placed in water they give birth to four gonidium-like swarming cells. Even before the commencement of the division of the contents by which the latter are formed, a change begins in the colour of the parent-cell, the red colour retreating to some extent from the periphery, and a yellow (sometimes rather greenish) border forming round the
deep red inner mass. The young swarmers also, for a short time after they issue out, have only a narrow yellow rim round a dark red middle. During the two or three days' period of movement and growth of these swarming cells—in which they grow to about four times the original size, changing their obtusely ovate form at the same time to a reversed pear-shaped apiculated shape—important new changes take place in the contents of the cells. The red colour becomes more and more concentrated into the middle of the cell, so that a sharply defined bright red nucleus is formed, in the interior of which a lighter space is often clearly perceptible, corresponding to the nuclear vesicle above mentioned, around which the red colouring matter forms a covering, mostly complete, but sometimes imperfect and interrupted. The rest of the cell-contents have become a brilliant green, and in them may be clearly distinguished the above-mentioned starch granules, as well as many more smaller green granules. The ciliated point of the cell, often drawn out like a beak, is colourless. This first moving generation is succeeded by a not yet accurately determined number of similar active generations populating the water for some weeks, and often giving it a bright green colour, till at length universal rest recommences, and the cells sink to the bottom, or attach themselves to the sides. The transition from one active generation to another takes place through a transitory resting generation of extremely short
duration. The full-grown swarming cells finally come to rest within their wide shirt-like envelope, and almost simultaneously divide into two cells, which, without becoming active, divide again into two cells. Thus within the mother envelope are produced four daughter-cells (more properly grandchildren), which begin to move soon after they are completely formed, and, tearing open the delicate enveloping vesicle, part company. The whole of this process of development is gone through very rapidly, being completed in one night and the succeeding morning. The second active generation, thus formed, resembles the first, with the single distinction that the active cells are green from the first, and have a smaller red nucleus in the interior. The subsequent active generations bear a general resemblance to the preceding, but many modifications present themselves. Thus, for example, we not unfrequently see the full-grown swarm-cells assume strange two-lobed, or even four-lobed, shapes, beginning to divide before they come to rest; or sometimes a transverse constriction and bisection of the cell takes place, caused by a partial protrusion of it from the loose shirt, etc. The formation of vacuoles is a pretty constant phenomenon in the later active generations, and there may be several of them eccentrically placed, with the red nucleus retaining its central position, or a single central vacuole, causing a lateral displacement of the red nucleus. This red nucleus often becomes very small in the last generations, so
that it very much resembles, especially when rendered parietal by the formation of a centre vacuole, the red corpuscle occurring in the gonidia of many genera of algae belonging to very diverse families, and which was called the 'eye' in the *Volvocineae* by Ehrenberg.

"A total disappearance of the red colour not unfrequently occurs. In the later stages of the cycle of generations arrives, finally, the formation of microgonidia; many individuals, instead of producing four daughter-cells, undergo further division, so as to give birth to a brood of sixteen or thirty-two minute cells, which, before they separate, form a mulberry-like body, but separating at length, commence a very active swarming inside the parent envelope, terminating in the rupture of this coat and the rapid dispersion of the little 'swarmers.' These are of longer shape than the large 'swarmers,' only about .0066, rarely .01 mm. long, of yellowish or dirty yellowish green colour, with reddish ciliated points. They do not exhibit increase of size, like the large 'swarmers,' never become coated with a perceptible and loose membrane, and have no further power of propagation. Most of them die after they have settled to rest, dissolving away; others turn into little red globules, and it is doubtful whether they can grow up to the normal size. If we now further examine how the cycle of active generations is closed and carried over to the resting vegetation, we find that the large 'swarmers'
of the last active generation, when their growth is completed and they have attained the stage of rest, instead of dividing again remain undivided, assume a perfectly globular form, and in the course of a few days become clothed by a thick, closely applied cell-membrane, while the earlier loose distant membrane gradually disappears. The contents, which at the commencement of the rest were all green, except the little red nucleus, or even often entirely green, now gradually become red again, passing from green through many tints of brown, or of brilliant golden green and golden brown, into red. These globular, thick-coated cells (the same as those with which we began) behave like seed-cells or spores, passing into a state of perfect rest. They do not exhibit any growth, and after the membrane has attained its proper thickness, and the contents their red colour, no further visible alteration takes place so long as they are kept in water. A dessication must take place before a new cycle of generations can begin. Perfectly dry specimens placed again in water ordinarily produce active gonidia the next morning. Original specimens, obtained in 1841, had retained their vital force during a preservation of seven years in a herbarium.

"In order to complete the main features of the picture of the alternating generations of this multiform creature, I must notice that, in addition to the described active generations (macrogonidia and microgonodia) and the concluding generation, passing into
the spore-like condition of rest, there are other genera-
tions which, as compared with the gonidium-like and
spore-like conditions, must be regarded as the proper
representatives of the vegetative development. These
are generations endowed with quiet and slow vegeta-
tive growth, which multiply by pure vegetative
division, unaccompanied by any swarming movement.
It depends solely upon external conditions whether
the resting cells, which are here characterized as seed-
cells (spores), at once give rise to the new active
generations, or to a series of quietly vegetating gene-
ations of cells. The former is the case when the seed-
cells are totally immersed in water, the latter when
they occur on a spot which is at once damp and
exposed to the air, as is the case in the native condi-
tion, especially in the milder intervals of winter, and
in the damp season of approaching spring, but tem-
porarily also at all other seasons, on the margins of
the little basins inhabited by Chlamydococcus, as often
as they are filled by showers of rain. In cultivation
in the house these vegetative generations are rarely
observed, while in their native stations they certainly
occupy the most important place in the alternations of
the various conditions of life, as may be concluded
from the thickness of the crusts and membranes formed
by such vegetative multiplication. The formation and
multiplication of these vegetative generations also
take place by the division of the cell-contents, either
by simple division, the first generation being transi-
tory, or by double halving (apparently quartering). But the newly formed cells do not slip out, like the young 'swarmers,' from the mother-envelope; they remain in the same place and position. The membrane of the mother-cell appears to become softened, expands, and becomes gradually drawn out to nothing, rather than regularly burst open; it at length vanishes in some undistinguishable way, the daughter-cells meanwhile acquiring a tolerably thick, closely applied cell-membrane of their own. The division is repeated many times in this way, and as the cells all remain in intimate contact, first small families, but by degrees large conglomerates of cells, are produced. The size of the single cells in these groups varies from 0.01 to 0.02 mm.; their shape is not truly globular, but partially bounded by flat surfaces, as results from the alternating divisions, according to the three directions of space. Ordinarily the colour is light brown. If ignorant of the rest of its history, one would be led by the form and mode of division of the cells to regard these crusts as belonging to a Pleurococeus. In the same crusts occur isolated large cells, loosened from their connection with the others, perfectly globular in form, and appearing to divide no more, but to have passed again into the condition of resting spore-cells. They are distinguished from the rest by their darker contents and thicker cell-membrane. Probably the return of these to renewed resting vegetation takes place by a passage through the series of active genera-
tions. Every shower of rain will wash away these loose ripe cells of the crusts of *Chlamydococcus*; carried into collections of rain water, they will soon produce the active brood, which, returning to rest after a few active generations, settles on the margins of the little puddles, and then recurs to the resting mode of vegetative multiplication."

Another example may be found in the well-known *Volvox*, the life history of which has been subjected to close scrutiny during the past twenty years. It has been shown that this organism affords an instance of true alternation of generation. "As may probably be affirmed of all living organisms, the life history would be incomplete without a process of sexual reproduction, and, accordingly, after a long sequence of asexual generations, a strictly sexual process intervenes, from which result certain spores destined to lie dormant for a while, and, like the zygospores of the conjugate algæ, to resist vicissitudes of condition and climate through the rigours of winter, and then to produce the parent form in the succeeding year, when external conditions again favour its development." *

A similar alternation takes place also in *Eudorina elegans*, and probably in all the members of the *Volvocineæ*. In his elaborate memoir of *Stephanosphaera*, Professor Cohn has demonstrated its existence,

by passage through numerous stages to a resting condition, from which originate new moving generations.*

CHAPTER X.

SPORÉ GERMINATION.

Even as there are many varieties of spores amongst the algae, so are there modifications in the modes of germination. There is perhaps a general similarity in all, accompanied by a variation in detail, but the similarity is most observable in the results.

It was an old notion, originating with Agardh, that the dark body which resulted from conjugation in the Zygnemaceae was not a true spore, but a kind of zoosporangium, which, after a time, did not germinate, but became resolved into zoospores, to which notion Hassall gave his adherence. As will be seen hereafter, the zygospores of this order pass into a condition of rest, but ultimately germinate and produce plants after the pattern of their parent. One spore one plant, is the normal condition, although in some cases, illustrated by members of other families, a division takes place in the contents of the resting spore, and a corresponding number of new plants are produced.

Young filaments, the results of germination, whether of fecundated spores, or the analogue of spores pro-
duced asexually, sometimes expand at the base so as to attach themselves from the commencement. In other cases there is no basal expansion, and consequently no attachment, but the resulting filaments are free swimming; this depends, however, on the habits of the parent-plant. After germination, and the gradual elongation of the filament, its growth and extension is dependent upon cell-division, and this proceeds regularly, and rapidly, to the full evolution of mature threads.

Spore germination in *Edogonium* takes place in the following manner:—"The fertilized oospore becomes a resting spore, which ultimately passes through these stages. Previous to germination, the spore has an egg-shaped figure; the cell-contents are densely crowded, and composed of minute brownish-green granules, closely surrounded by a distinct cell-membrane. Outside this membrane there is found besides quite a distinct cell-membrane. Upon germination there are formed in both membranes slit-like openings, through which the cell-contents emerge, surrounded by an extremely delicate hyaline covering. The cell-contents are composed not of one, but usually of four green masses, each surrounded by its cell-membrane. Sometimes also, as it appears, abnormally, the masses are two or three in number. The four cells which proceed from germination possess an oval form, and their cell-membrane is hyaline. After the contents of the spore have emerged there remains behind the outer membrane,
enclosing the inner one. After the four cells have remained some time enclosed in the hyaline covering, this becomes resorbed subsequently, and the four cells lie still and motionless; but after the course of a short time the cells burst on one end by means of an annular slit, and the apex, separated thereby from the remainder of the cell-membrane, become elevated like a lid. Through the circular opening the cell-contents now emerge, and this, at the part turned towards the opening, is colourless. This apex moves with vigorous motion backwards and forwards, and after an hour the cell-contents, in the form of a zoospore, leave their place of detention, which we now find to be a doubly coloured cell-membrane. The little zoospore wheels about in a lively manner, with a circling movement, whereby the colourless point becomes directed downwards. Its appearance is like that of an ordinary zoospore, and, like it, possesses an oval form and a lighter apex, furnished with cilia, which during the motion is always directed forwards. After a time the movements become faint, and finally cease. The cilia disappear, and the light end becomes elongated into a root, which sometimes becomes an organ of attachment quite like that produced in the germination of the ordinary zoospores. The rounded end of the germinating zoospore acquires a little point-like apex. This growth becomes divided by a transverse septum, and a little two-celled *E*dogonium has originated. From each spore there are thus derived, in general, four plants.
It is worthy of note that so long since as 1846, Mr. G. H. K. Thwaites observed a similar phenomenon of the division of the contents of the spores in *Mesocarpus* into four portions. In three species this peculiarity was observed and confirmed by the Rev. M. J. Berkeley. "The separation," it is remarked, "of the contents of the spore into four portions does not take place in our three species until the fruit is nearly mature, and this soon afterwards becomes too opaque for the character to be seen, so that it can be observed only in a particular state of the plant."* Alexander Braun, in reference to this, admits that "the observations of Thwaites, who saw the contents of the ripe spore separate into four portions in certain *Zyggnemaceae*, particularly *Mesocarpus* and *Staurocarpus*, testify that a formation of several germ-cells or young plants in one spore may occur in this family."

The ordinary germination of the spore in *Spirogyra* is not, however, associated with the breaking up of the cell-contents into four germinating bodies.

The changes which the spore does undergo previous to germination were faintly indicated by Braun, when he wrote, "The contents of the spore appear totally changed when it is about to germinate; the multitude of large and small oil-drops has vanished, and the opaque mucilage, now become green, again exhibits, but indistinctly, a few small drops or vesicles. Newly formed spiral bands become visible as dark, very

* *Annals of Natural History*, xvii. (1846), p. 263.
closely approximated, frequently somewhat flexuous, oblique streaks, even before the germinating internal cell has broken through its double envelope."

For information as to the process of germination in Spirogyra, we are indebted to Pringsheim's memoir.* "Conjugated specimens of Spirogyra jugalis, collected in August, maintained themselves in this condition through the winter, in my room, in a little glass vessel full of water, to the bottom of which they gradually sank. Some spores germinated as early as February, but most of them did not open until April, so that some eight months elapsed between their formation and their germination. We observe in the spores of Spirogyra, as in all motionless spores of algae, a long period of rest between formation and unfolding; yet, during this time of apparent rest, processes are unceasingly active in the interior of that germ, not immediately manifesting themselves to the eye, but resulting in effects which may be detected in the spores of Spirogyra in demonstrable alterations of the contents, and of the membranes of old spores. Immediately after formation the spore possesses only one single, perfectly colourless, thin membrane, composed of pure cellulose. In many spores this is still so thin for a short time after the formation of the spore, that it is incapable of withstanding the strong endosmose excited by the addition of sulphuric acid, and bursts

at some point, allowing the escape of the contents. The contents of the new-formed spores consist of the almost unchanged spiral bands of the cells concerned in the formation of the spore, contracted far more closely than in the filament cells, but retaining their form scarcely changed. The older the spores grow the more does the form of the spiral bands in their interior disappear, and their contents become uniformly diffused over the entire inner surface of the spore membrane. Finally, just before germination, the original spiral arrangement is still indistinctly indicated by several close spiral streaks in the coating, spread uniformly over the wall. It is a peculiar circumstance, that during this time the spiral arrangement of the contents of the spore presents itself, sometimes distinctly, and sometimes indistinctly, and almost wholly vanishes at the moment of germination, but always appears with surprising clearness when the spores are left for some time in glycerine, or are allowed to become perfectly dried up. Chemically speaking, the contents of the spore appear to be more changed in the relative proportions of quantity of the particular constituents than in their quality before germination.

"The differences between the membranes of old and young spores are more important than the changes perceptible in the contents. Instead of the one colourless membrane of the young spore, this latter exhibits, shortly before germination, three distinct
membranes, not blended together. These are minutely described. The detection of the three membranes is very rapidly effected by the application of concentrated potash. After the transformation of the contents is terminated and the formation of the two inner membranes completed, the germination of the spore commences by a growth of the internal cell, formed by the inmost membrane. The increasing size of the internal cell first causes the yellow (median) membrane to break across in an irregular crack, and, after a further growth of the germinating cell, the outer colourless membrane tears in a similar manner. This succession of the bursting of the outer coats of the spore is caused by the structure of the spore and the unyielding rigidity of the middle coloured coat. The internal cell, bursting forth from the coats, grows in the course of a few days into a longish cell, which soon presents septa, and becomes a many-celled filament, which resembles the parent both in the number of spiral bands and in dimensions. Even in the unicellular condition, one end of the cell is elongated in a tubular form. The green spiral bands do not extend into this always unbranched, radical extremity, and, its further growth being restricted, it remains fixed from an early epoch, at that stage of development which it has attained in the young, few-celled plant, while the opposite end of the spore is capable of unlimited elongation, by uninterrupted growth, and repeated formation of septa.
“The end of the young plant, no matter whether it was the radical extremity or the growing summit, remained sticking in the burst coats long after the emergence of the other end, and the envelopes were not thrown completely off until a late period, and then either accidentally or, as mostly occurred, by the young plant rising from the bottom of the water, where the germination took place. I never saw the liberated young plant become attached to anything by its radical extremity, and this corresponds to the ordinary floating condition of the Spirogyrae. But I cannot decide whether or not the Spirogyrae become fixed to anything by their root-cell at a later stage than that to which I was able to trace the young plants. It is probable, however, that those Spirogyrae which are found adherent in their natural stations use their root-cell as the organ of attachment.”

In Sphaeroplea annulina the resting spores are red spherical bodies formed of two hyaline membranes, the interior of which is intimately connected with its plastic contents, whilst the exterior is loose and elegantly plaited. These plaits, or folds, are so arranged that they meet at their two poles; often, however, they are very irregular in shape and direction, especially in the larger spores. In germination, according to Cohn,* they undergo several modifications. They become granular and change to a dull

brown red, and a more transparent circle appears in their centre. Frequently the red matter changes to green before the germination, and this change is gradual, proceeding from the circumference to the centre. At length the whole of the plastic contents divides into two, then into four or eight bodies, which burst the double envelope, and disperse in the water, as so many zoospores.

"The zoospores are of an elegant shape, but this is not more uniform than their size or colour. Usually they are globular or shortly cylindrical bodies, from $\frac{1}{150}$ to $\frac{1}{30}$ of a line long, of a beautiful cinnabar or carmine red, and furnished at one of their ends with a small colourless head bearing two long cilia. Some of them are larger, pyriform or fusiform, and the result probably of the undivided contents of a resting spore. Some of the zoospores are two-coloured—red towards the beak, and green throughout the other part, or the two colours are variously disposed, the colourless head or beak, and the two cilia are invariably very distinct. The zoospores exhibit a slow jerking movement during several hours. This movement is often interrupted for several hours, when the whirling suddenly recommences. When the zoospores break through the integument within which they are formed, they are not enveloped in cellulose, but already during their period of activity they begin to invest themselves with a thin elastic pellicle. At the time of their germination this envelope
INTRODUCTION TO FRESH-WATER ALGÆ.

thickens and lengthens in the form of a spindle, the two ends soon tapering off into long tails, whilst even the enlarging body of the zoospore itself separates farther and farther apart. The contents of this germ-cell, at first homogeneous and finally granular, change during this first growth. What is left of the red oil is quickly transformed into chlorophyll, and the plantlet assumes a uniform green colour. Nevertheless one may perceive from the beginning a number of vacuoles, or limpid, colourless droplets, in the midst of the protoplasm with which they are filled, and between them the chlorophyll collects in rings more or less distinct from each other. Soon large grains of starch appear in these collections of green matter, so that the plantlet combines all the characteristics of an adult cellule of the Sphaeroplea, even before it has exceeded a thirteenth of a line in length. The terminal tails have been observed after the plantlet was more than half a line long. Growth takes place in the middle, by the successive division of the older rings."

The macrospores of Hormiscia zonata are of a thick short pear-shape, furnished with four cilia. After a time they come to rest, and, fixing themselves by the ciliated end, lose their cilia and develop a membrane; in this condition they seem to acquire the functions of a spore, without the intervention of fecundation. The fixed end develops into a root-like colourless organ of attachment; the free end growing into a club-
shaped plantlet, through the cell dividing into two by a cross partition, and each of these again in two, and so further. So also microzoospores remaining behind in the mother-cell, unable to copulate and pass through their stages after the normal manner, are capable of germinating within the mother-cell, and developing into independent plants.
CHAPTER XI.

SPONTANEOUS MOVEMENTS.

Interminable discussions have been carried on, with practically very feeble results, as to the causes of spontaneous movements in algae. We have advisedly omitted Diatoms from this work, as an isolated group which could better be studied by themselves, but the movements of Diatoms have been one of the most fertile themes of discussion. Some savants were led to the conclusion that they must be animals; others maintained them as plants.* The Desmids, also, another isolated and excluded group of fresh-water algae, have been fertile in discussion. Still amongst the remainder there are known instances of spontaneous motion, which have been constituted puzzles for the curious. The movements of the ciliated zoospore long held to be infusorial is a case in point, whilst certain amœboid structures and amœboid movements have led to a wavering of faith in the continued and persistent vegetable nature of algae, under all circum-

* Meneghini on the Animal Nature of the Diatomæ (Ray Society), 1853.
stances and conditions. The *Oscillarieæ*, with their peculiar and oscillating movements, have been subjected to scrutiny, and have not wholly escaped condemnation on the ground of this erratic tendency. Without assuming any special inspiration to explain these phenomena and set the question at rest for ever, it may be permitted to allude to some of them, as presenting interesting problems still remaining open for illustration and solution.

Active motile cells are so common amongst algae that they scarce need description. It is true that they have been honoured with many names, such as active gonidia, zoogonidia, zoospores, etc., etc., but in the main they are minute corpuscles, endued with active movement, caused or accelerated by the action of one, two, or more of vibratile cilia; what they may ultimately become in part determines the name they shall bear. In many cases they are produced in immense numbers, and swarm out of the cells in which they originated. They may have been produced without any known act of fecundation, or they may have had a sexual origin. In themselves they may be objective or passive, male or female, but externally there is very little essential difference between them. They are single cells, more or less globose or elongated, bearing cilia at one extremity and capable of spontaneous motion. When locomotion was thought to be an attribute of animal life, these little bodies were held to be animals, and supposed parasites.
Now that locomotion is not believed to be confined to animals, these corpuscles are reckoned amongst the phases of vegetable organisms. With objects so minute it is difficult to investigate so as to be able to give a satisfactory answer to the question how the motion is produced. That it is caused by the rapid movements of the cilia, no one has called in question, but what is the power which operates upon the cilia has not yet been determined, and wherein does the source of motion differ from the same source in animals is unanswered. There is no absolute reason why the motive power should be different, in zoospores, to what it is in infusoria of the same dimensions and simplicity of structure. This is not a problem which is readily determinable.

The movements of such compound bodies as Volvox, Pandorina, Eudorina, and Gonium have been regarded as mysteries in the past, when microscopes were too imperfect to resolve them; but no longer are they relegated to the animal kingdom on account of their spontaneous movements, since these are dependent upon the impulse of the individual ciliated zoospores of which the colonies are composed. "The combined action of the pairs of cilia in which the gonidia terminate is the actuating power whence proceed both the rotatory and the progressive movement of Volvox, and these are both in a definite direction. If an imaginary axis be drawn through the sphere, the progressive motion being, so to speak, from the north to the south
pole of that axis, the rotatory motion is usually from west to east, though not always, being occasionally reversed for a few seconds; but for the greater part of the time it is regularly in the direction indicated." * In Pandorina, the individual groups are at first motionless, and the mother plant loses its cilia during the formation of the young ones; the entire group is at first quiescent. But afterwards the young sexual plants, like the neuter ones, produce upon each of their cells two cilia, which commence their motion as soon as the enveloping mucus admits of it, and thus ultimately the entire group assumes a state of active rotation. In Gonium, and also in Stephanosphaera, the colonies rotate, each on its axis perpendicular to the plane in which the primordial cells are arranged, and move actively in space, by the aid of cilia, two of which proceed from each of the primordial cells, and pierce the hyaline envelope.

To the novice nothing will appear more remarkable in the movements of algæ than the behaviour of the gonidia and antheridia in acts of fecundation. If certain species of Edogonium are selected for illustration, these movements will seem so near akin to animal instinct as to occasion surprise. The selected species will be one of those in which dwarf males are produced from certain privileged cells of the filament which bears the oogonium, or female cell. The oogonium is more or less oval and inflated, and

* Wills on Volvox in Midland Naturalist, September, 1880.
encloses the oospore which requires to be fertilized. To assist in this process the upper portion of the oogonium splits round and opens, like a lid, or operculum; or else there is a pore or opening in the side wall, for the admission of the male element. In due time some short and specialized cell of the same filament produces in its interior an active zoospore, which escapes by rupture of the cell-wall. This escaped zoospore (called androspore) floats freely in the water, but soon attaches itself by the ciliated end either upon, or closely beside, the unfertilized oogonium, and in that position undergoes a further development into a dwarf male plant, having the form of an inverted flask, seated upon a more or less elongated stem, the apex opening by a lid or cap when mature. In the upper portion of this dwarf male spermatozoids are developed, and these at length escape through the opening at the top, and, swarming around the oogonium, enter it by the pore, or the raised operculum, to fertilize the oospore. In all these movements nothing seems to transpire by accident. The androspore attaches itself in a convenient position for the resulting male to fertilize the oospore, and, when the spermatozoids are expelled, this action takes place in close proximity to the opening in the oospore.

In this same genus, *Edogonium*, there are other species, in which the androspores, which result in the production of dwarf males, are not developed from
special cells of the same filament which bears the oogonium, but upon separate male filaments which only produce androspores. In such case the escaped active zoospores, or androspores, have to seek out for female filaments, and select upon them, when found, an eligible position for development into dwarf males, so that the escaping spermatozoids shall be in close proximity to the unfertilized oospore. This power of selection seems indisputable, as we do not find the dwarf males established upon male filaments, or on sterile portions of female filaments, where their energies would be expended in vain, and their functions unfulfilled.

Of less interest, because less remarkable, are the movements of the ciliated zoospores, or spermatozoids, in *Sphaeroplea*, which are produced in large numbers within the filaments, and ultimately escape into the surrounding water. These rod-shaped bodies have a somewhat expanded posterior extremity, which is often flattened, and a long narrow beak, armed with two cilia, at the other extremity. When discharged by rupture of the mother-cell, these active bodies become diffused, but soon assemble around the filaments enclosing unfertilized female zoospores. The walls of these cells are perforated, and the rod-shaped corpuscles may soon be seen struggling to enter the little orifices, with the beak foremost. Sometimes three or four may be seen struggling to enter the same orifice. The more slender corpuscles make their
way, at the first attempt, in a remarkable manner, swimming in wide curves, from the water, through the hole into the cavity of the cell, and the act of fecundation is accomplished.

Certainly one of the most singular of experiences in the life history of fresh-water algae has been the discovery that, under certain conditions, they assume the form and habit of an *Amœba*. It is well known that the organism which goes by the name of *Amœba* is recognized as an animal, very low in the scale, it is true, but still an animal, and a rhizopod, without any special organs, but capable of slow locomotion, undergoing constant change of form, and conducting itself like a simple animal. At first it seemed almost incredible that, under any conditions, algae should be metamorphosed into such a body as should in itself be scarcely distinguishable from an *Amœba*, yet the evidence is so strong as to leave no ground for doubt. Not only simulating *Amœba*, but in some cases a closely related rhizopod, well known to microscopists as *Actinophrys*. We will, however, proceed with the facts.

The first authority is Dr. Braxton Hicks, and his observations relate to *Volvox*. He says, "The first example in which I observed motion in the cell was at an early period, before the young *Volvox* is fully grown, at the time when the future zoospores first appear, enclosed in cells, the final product of segmentation. These zoospore-containing cells, by contact with
their neighbours, are rendered multiangular, and they include about twenty or thirty hexagonal young zoospores, in close contact, and which are of many colours. When these cells are detached they become round, and they have a curious power of changing shape, like an infusorial *Proteus*, protruding the wall first at one side and then at the other, into which protrusions the contents run. The other and more striking instance, however, was visible in the zoospores themselves at an advanced age, when some of them enlarge and become irregular in outline. Some disappear; some break up and disperse within the *Volvox*; some undergo a process of subdivision, producing a group of from two to forty green drops, arranged so that their apices, with cilia, point externally; while others enlarge to two or three times their natural size, having many nuclei within, and variously coloured. When this cell, probably by the solution of the outer mucilaginous coat, becomes free, it also possesses the power of moving precisely as does a true *Amœba*.” Setting aside the suggestion that they must be animals, because in some phase of their existence they possess a self-moving endoplast, he proceeds to give his own interpretation, “That the protoplasmic contents, when deprived of their confining envelope of cellulose, possess, in common with sarcode, under certain circumstances, a power of spontaneous motion in the manner of an *Amœba.*” *

Subsequently the same author confirmed his previous observations, and detailed fresh instances, in which he had seen the zoospores of *Volvox* taking the amœboid form, and possessing the power of protruding and retracting, in various parts, portions of the primordial utricle, exactly and to the full extent of a true *Amœba*. By this power they glide along the inner surface of the sphere, among the unchanged zoospores, and when they come in contact with one, they bend themselves around it in the manner of the *Amœba*.*

In a long and elaborate communication on *Stephanosphaeria pluvialis*, Mr. W. Archer describes the development of amœboid bodies in that species, confirming in a remarkable manner the observations of Dr. Braxton Hicks. "I was very greatly astonished," he writes, "to find the slide to a considerable extent crowded by a number of what appeared to me to be *Amœbœ* of some undescribed species, and these in active movement, gliding about and crossing each other in every direction. These were certainly not to be seen when I last looked at the slide, and the phenomenon was, beyond measure, puzzling. I therefore rigidly examined them. It will readily be believed that my astonishment was beyond measure great upon shortly, beyond all question, identifying these vigorously active *Amœba*-like bodies with the just previously quiescent primordial cells of the *Stephanosphaeria*—nay more, in watching the transformation

of the latter themselves into the creeping amoeboid bodies, putting a parasitic development wholly out of the question; it will readily be believed, I say, that my astonishment was beyond measure great in actually witnessing with my own eyes this, at first sight, sufficiently startling phenomenon. What! a plant, an undoubted true chlorophyl-containing, cellulose-bounded alga, become metamorphosed into an animal! For my part, indeed, even after witnessing the wonderful change now mentioned, I could not acquiesce in such an assumption; and, so far as I can see, in my humble judgment, those who might be disposed thus to understand it would greatly misinterpret the phenomenon.”* We need not detail all the process of transformation, or reproduce the valuable remarks which go to make up this long and most interesting communication, but accept the facts, as above stated.

We have yet another witness for the conversion into amoeboid forms in *Chlamydococcus pluvialis*, as observed by Mr. Charters White. He says, “My impression, derivable from an examination of many *Amœbae*, is that they are the results of changes from the protococcal state, that they are vegetable; but of course this phase of the subject remains for future investigation. It appears to me that the structureless envelope becomes the homogeneous part of the *Amœba*,

while the granular centre becomes the granular \textit{Amoeba}. This conclusion is derivable from, and is the result of, the collation of many observations made since last spring, and ought not to be deemed beyond the bounds of probability, inasmuch as some of the former writers on these subjects mention the rhizopodous development of the contents of \textit{Euglena} into granuliferous \textit{Amoeba}.”

It only remains to cite another authority, and in this instance it relates to the development of forms related to or simulating the kindred rhizopod \textit{Actinophrys}. Whether the development is of the same kind as those above enumerated may be open to doubt, but the phenomenon is, in any case, of considerable interest. This development took place in the cells of \textit{Spirogyra crassa} in the following manner:—“Under certain circumstances the cell of the \textit{Spirogyra} apparently dies, the chlorophyl becomes yellow, and the protoplasm divides into portions of different sizes, each of which encloses more or less of the chlorophyl. These portions travel about the cell under a rhizopodous form; the chlorophyl within them turns brown; the portions of the protoplasm then become actinophorous, then more radiated, and finally assume the figure of \textit{Actinophrys}. The radii are now withdrawn, while the pellicle in which they were encased is retracted, and hardened into setæ with the rest of the pellicle,

which now becomes a lifeless, transparent cyst. Another more delicate cyst is secreted within this, and the remains of the protoplasm within all having separated itself from the chlorophyl, divides up into a group of monociliated monads, which sooner or later find their way through the cysts into the cell of the *Spirogyra*; while the latter by this time having passed far into dissolution, they thus easily escape into the water.

"At first it did not appear plain why the portions of protoplasm enclosed the chlorophyl, but afterwards it was found that this was for the purpose of abstracting the starch which accompanies the latter, since in some cases where the grains of starch were numerous the chlorophyl was not included.

"This was the process when the cells of *Spirogyra* were not pregnant with starch, as they are just before conjugating. When these changes took place at this period they were somewhat different, insomuch as the whole of the contents of the two conjugating cells become united into one mass, and, having assumed a globular form, remain in this state until the chlorophyl has become more or less brown. After this the protoplasm reappears at the circumference of the mass in two forms, viz. in portions which leave the mass altogether, after the manner of rhizopods, and in the form of tubular extensions, which maintain their connection with the mass throughout. In both instances the protoplasm is without chlorophyl, but
charged with oil globules, and both forms make their way to the confines of the *Spirogyra* cell, which they ultimately pierce, develop their contents, and discharge them in the following manner:

"On reaching the cell-wall, each form puts forth a minute papillary eminence, which, having passed through the wall, expands into a large sac, or bursts at the apex. Following the isolated form first, this then gradually drags four-fifths or more of its bulk through this opening, sometimes so much as only to leave a little papillary eminence in it, which then makes the portion of protoplasm look as if it were entering instead of escaping from the *Spirogyra* cell. The internal contents of this protoplasm then become more defined and granular, the granules assume a spherical form respectively, they evince a power of locomotion, and the originally flexible pellicle, having become a stiffened cyst, with a more delicate one within, assumes a slightly conical form, which, giving way by a circular aperture at the apex, allows the granules to pass into the water, when they are seen to be monociliated monads, each consisting, apparently, of a film of protoplasm expanded over an oil globule, and bearing a single cilium. The contents of the tubular form, on the other hand, undergo the same changes, but the tube becomes dilated into a pyriform shape, within the *Spirogyra* cell; and when the monads are ready to lead an independent existence, the end of the papillary eminence, which has been projected some
little distance beyond the cell-wall into the water, gives way, and thus they also escape."

After some further details and observations, the writer adds that "whenever a mass of filaments of *Spirogyra* underwent these transformations, the latter were invariably followed by a numerous development of *Actinophrys sol* of all sizes, to the exclusion at first of almost all other animalcules; and, coupling this with the undistinguishable form from *Actinophrys sol* assumed by the monads developed by these transformations, he saw no other more reasonable conclusion to come to than that they were one and the same, and therefore that one source at least of *Actinophrys sol* was the protoplasm of *Spirogyra.*"* In plain words, he thinks that from the protoplasm of a vegetable alga the animal rhizopod becomes eliminated—a conclusion with which we are not prepared to concur.

Under the designation of abnormal spore-formation, Braun seems to allude to the phenomena we have described; for he says, "The character of these abnormal cells is most varied and changeable. Especially remarkable is the recurrence of globular, resting, spore-like cells (in old *Closteria*), as also the appearance of active infusoriioid structures, which occur not unfrequently in the interior of decaying cells of green fresh-water algae (*Edogonium, Spirogyra*), and are distinguished from normal swarming cells by their irregular form, varying size, slower motion, and mostly

brownish-yellow contents, succeeded by hyaline, finely granular mucilage. Abnormal structures of this kind have doubtless often been confounded with the normal reproductive cells of the algæ. The future will certainly unfold many interesting phenomena in this hitherto little-worked field.” *

That well-known algologist, Mr. Archer, of Dublin, has some pertinent remarks on a phenomenon which he observed in connection with Botryococcus Braunii. More than once, when a single group, or family, of this alga, from gatherings kept for some time in the house, had turned up under a low power of the microscope, he had been to some extent deceived by the way in which it resembled some radiolarian rhizopod. The mucous matrix containing the families of cells seems not unfrequently to give off rather long filiform prolongations, which stand out more or less radiantly, looking not unlike pseudopodia, and these are undoubted rhizopods containing chlorophyl. It might, indeed, be a good example of two objects with no affinity in any respect to each other, still superficially stimulating one another.†

The oscillation of the filaments in the Oscillarice is a fact so prominent and remarkable that it gave origin to the name by which this family is known. It is forty-five years since Hassall wrote of them in terms which can hardly be changed by subsequent

* Braun on Rejuvenescence (Ray Society), p. 281.
† Cooke, “Fresh-Water Algæ,” p. 17.
knowledge. He says that the majority of the species are distinguished "by a peculiar oscillation, with regard to which I can myself perceive nothing extraordinary, although the phenomenon is certainly peculiar to this family—nothing indicative, as most suppose, of a sensitive or animal life. The explanation to be given of this oscillation of the filaments I consider to be partly of an external, and entirely of a physical character. It has been stated that the filaments of very many species, and, indeed, of all those which present the phenomenon of oscillation, are remarkable for their straightness or rectitude, which is due to a certain degree of elasticity belonging to them, and which leads to the effort on their part, whenever, as on being placed for observation on the field of the microscope must be the case, they are bent or put out of a straight line, to recover that position which is natural to them. This elastic property of the filaments, currents almost imperceptible in the liquid in which they are immersed, and perhaps unequal attractions amongst the filaments themselves, are causes amply sufficient to explain any motion which I have ever witnessed, and which motion I cannot help thinking to have been misunderstood, and exaggerated to such an extent, as to throw around these plants an unnecessary degree of mystery."*

Professor Schnetzler had not practically got much

* Hassall's "British Fresh-Water Algae" (1845), vol. i. p. 244.
further than this in 1835, when he gave, as the results of his investigations into the movements of Oscillaria, the division of those movements into six different kinds: (1) Of rotation round the axis of the filament or its segments; (2) creeping or gliding over a solid substratum; (3) a free movement of translation in the fluid; (4) the rotation or flexion of the filament; (5) sharp tremblings or concussions; and (6) radiating arrangement of the entangled filaments. This writer considers that simple osmose is not sufficient to explain all these various movements, but that they must be due, in some way at present unexplained, to the protoplasm. Everything which increases or retards the vital energy of the protoplasm increases or retards respectively the intensity of the movements of the filaments.* It must be confessed that, whether attributed to external influences and elasticity, or to internal energy of the protoplasm, the explanation has yet to be given of the causes, and their mode of operation, of the oscillation of the filaments of Oscillaria (Fig. 99).

CHAPTER XII.

NOTABLE PHENOMENA.

There are a few phenomena which partake of the mysterious, or at least are remarkable, to such an extent as to claim a little notice in a work of this kind. Some superstitious regard attached to certain of these phenomena when their causes were absolutely unknown, and, even now, there are many who are content to wonder at the manifestation, and do not seek behind them for their elucidation.

"Breaking of the Meres" is a phrase which represents certain phenomena in still inland waters which the uneducated marvel at because they cannot comprehend. Much speculation has been indulged in as to its cause, but the true interpretation seems to have been reached by a small committee of a local society, which was appointed to investigate the meres of Shropshire. The report states that "An interesting phenomenon occurs at certain seasons of the year in this (Ellesmere) and some of the other meres, which the people of the neighbourhood are accustomed to call 'breaking of the water,' or 'breaking of the
mere.' To a stranger these terms are somewhat misleading, as they appear to suggest a violent agitation of the water, or its bursting through its banks, whereas the phenomenon resembles the breaking of wort in the process of brewing, causing a discoloration of the water, rendering it unfit for consumption, and spoiling the fisherman's sport. In its normal condition the water is pure and limpid, perfectly suitable for domestic purposes, but when it breaks it becomes turbid from the formation of small dark-green bodies, in countless thousands, which not only float as a scum on the surface, but abound throughout the whole of the water. The change is so apparent that it cannot escape the notice of the most careless observer. On examining the floating matter of Ellesmere, the green bodies composing it are found to be rather smaller than a turnip seed, spherical in form, and of the deep green colour familiar to us in the rust of copper. Their specific gravity must be nearly the same as that of the water, which will account for their rapid dissemination throughout it when disturbed, and rising to the surface when at rest. This mere abounds in fish, and is much frequented in the proper season by anglers, but as soon as the breaking begins all sport invariably ceases, and the fish become torpid, refuse the bait, and sulk at the bottom. Whether this curious effect upon them is caused by some injurious gases generated at the time, or by the minute green bodies already mentioned
entering their gills and impeding respiration, is a question not yet determined.

"Various popular explanations have been given of this breaking, the more generally accepted one being that it results from the seeds of aquatic plants, growing on the margin of the mere, falling into the water; and there is some probability on the face of this explanation, because it generally occurs in the autumn, when plants begin to drop their seeds, and the green bodies somewhat resemble a minute seed. In 1878 the late Rev. W. Leighton pointed out that the real cause was the rapid germination of a minute plant classed amongst the algæ, and formerly known as *Confera echinata*, but which, he intimated, should, according to modern classification, be called *Rivularia articulata*.”

Proceeding to a microscopical examination of the water, the following may be regarded as a summary of results obtained by this committee:—"It is necessary to remark that the phenomenon called 'breaking' must be distinguished from a turbid or muddy state of the water, produced by heavy rains washing down vegetable fragments and earth. If we examine water under the microscope changed in its appearance by this latter cause, we do not find one or two small vegetable organisms pervading the whole body of water, imparting to it their own peculiar colour, as in true 'breaking.' Nor must we confound with it an occasional and partial occurrence of algæ in small
quantities, for at any time during the year interesting species of these minute plants can be found, by diligent searching, in nearly every gently running stream, quiet pool, and mere. It can be most readily detected by the uniform dark-green colour of the water, or by the floating scum in the quiet bays on the leeward shore; but in such cases it is best to take up a small portion in a white glass bottle, and look through it with a pocket lens, when well-defined forms will be detected, though too small to admit of their structure being seen. A good microscope will at once show the myriads of beautiful green bodies—true plants—which are present. To convey some idea of their number, I took a common pin, put the head of it in water collected in Newton Mere, and thus obtained a small drop, and on placing this drop under a microscope I could clearly count 300 individual plants. I must leave it to the reader to calculate how many must be present to colour the water of a mere 115 acres in area."

The different species of algae found in Shropshire meres causing, or contributing, to the "breaking" were *Rivularia echinata* (articulata), *Anabaena Hassallii*, *Coelosphaerium Kutzingianum*, *Anabaena Ralfsii*, and *Aphanizomenon flos-aquae* (Fig. 96).

It must not be inferred that this "breaking of the water" is confined to Shropshire, for a similar pheno-

menon was recorded many years ago, by Professor Dickie, in Scotland, and two of the same species of alge were concerned in its production. "For some years," he says, "excursions were made with the students of my botanical class to a loch on the estate of Parkhill, about four miles north-west from Aberdeen. The sheet of water in question is about a quarter of a mile in its greatest length; on almost all sides it is surrounded by extensive deposits of peat, with a soluble matter of which a great proportion of the water passing into the loch is impregnated. The locality was generally visited in the beginning of July; nothing peculiar had ever been observed till the autumn of 1846, when my attention was arrested by a peculiar appearance of the water, especially near the edge, but extending also some distance into the loch. Numerous minute bodies with a spherical outline, and varying in size from one-twenty-fourth to one-twelfth of an inch in diameter, were seen floating at different depths, and giving the water a peculiar appearance. In some places they were very densely congregated, especially in small creeks at the edge of the loch. A quantity was collected by filtration through a piece of cloth, and on examination by the microscope, there could be no doubt that the production was of a vegetable nature, and a species of *Rivularia*; one, however, unknown to me. Specimens were sent to the Rev. M. J. Berkeley, who informed me that the plant was *Rivularia echinata* of
164 INTRODUCTION TO FRESH-WATER ALGÆ.

the English Botany. Along with it, but in very small quantity, I also found another plant, *Aphanizomenon flos-aquæ*.

"In the first week of July, 1847, the same species were observed similarly associated, but the *Aphanizomenon* was now more plentiful, without, however, any apparent corresponding diminution in the quantity of the *Rivularia*.

"In July, 1848, it was observed that the *Rivularia* was as rare as the *Aphanizomenon* had been in 1846; to the latter, consequently, the water of the loch now owed its colour, which was a very dull green; the colour, however, becomes brighter when the plant is dried. In neither of the seasons mentioned was it in my power to make any observations on the colour of the loch earlier or later than the date above-mentioned, consequently nothing can be added respecting the comparative development of the two plants at other periods of the season. Other two lochs in the vicinity did not contain the plants alluded to." *

It is not at all improbable that the *Oscillatoria (ærugescens)* mentioned by Professor Drummond as giving colour to a lake in Ireland may have been associated with some such a phenomenon. The professor commences by stating that "Glas-lough" signifies "green lake," an appellation given to it from time immemorial on account of the hue of

its waters, which exhibit a green tinge, equal to, or exceeding in intensity, that of the sea, though it is not at all times equally striking. "From the accounts I received, the green colour is evident in the lough throughout the year, and if I may judge from my own observations, every drop of it is impregnated with the oscillatory filaments. When a little of the water is lifted in the hand it seems perfectly transparent, and it appears equally clear at the edges of the lake, but at a depth of two feet the bottom is indistinguishable, and the water presents a sort of feculent opacity, accompanied by a dull, dirty, greenish hue. On lifting some of this in a glass, it seems at first sight quite transparent, but on holding it up to the light innumerable minute flocculi are seen floating through every part of it, and producing a mottled cloudiness throughout the whole. At first I could only find the plant diffused through the water, but at length I discovered a wet ditch extending from the lake into an adjoining field, and there it appeared swimming on the surface in large masses several inches in thickness, and above a foot and a half in length. These seemed evidently to be produced by an agglomeration of the filaments floated in from the lake, matted together at the surface, and increased in growth. The surface of these masses, where dried by the contact of the air, was of a bright bluish verdigris hue, while the parts immersed in the water were of a dull opaque green.
"On examining specimens in the microscope, I sometimes observed their motions to be very vivid, and in other instances little or no motion could be perceived. They were extremely minute, their transverse striae very numerous, and at distances of about half a diameter from each other. The filaments in the conglomerated masses appeared to me to be many inches long, and running parallel together; the broken fragments dispersed through the lake cross each other in all directions." *

These phenomena are evidently not confined to our own islands, for Professor Cohn refers to something very similar, which is known in Germany as "Water-blossom." "Though the appearance has often been observed and examined," he says, "very little is known of the causes from which it originates. Within the course of a few hours an alga so densely covers a vast extent of the surface of the water, that it imparts to it a distinct colour, green, brown, or red; sooner or later it disappears, either periodically, or altogether. The only reason for this that can be assigned, apart from the extraordinary increase of the respective species, is the sudden change of their specific gravity, which causes them to rise suddenly from the bottom of the water, where they are developed in vast numbers, to the surface, and as suddenly to sink down again." As a specific instance, he alludes to the Leba, near the Prussian frontier. "This Leba is a true moor

* Annals of Natural History (1838), i. p. 1.
river; its banks are quite flat, the bed is nothing but moor and swamp, which gives way under one’s feet. Whenever the river is about two feet deep, the water takes a brown colour, which prevents people from seeing to the bottom. On July 19, 1877, the river appeared quite green, from a vast quantity of minute spherical bodies which floated on its surface, and even ordinary people were struck by it. The phenomenon, which was first noticed towards noon, lasted for about five hours, and had totally disappeared in the evening. The next morning there was nothing to be seen, but at noon there was again a large quantity, whilst there were very few towards night. It was similar on the third day, but since then the minute spherical bodies have entirely disappeared from the Leba.”

Undoubtedly this “breaking of the meres” is not the unmitigated evil which is attributed to it by disappointed anglers, but has some moral, some good service, perhaps by clearing off the carbonic acid gas produced by decay of organic matter, at any rate by clearing and sweetening the water; perhaps also, not a little, in furnishing a supply of food to minute animal organisms; at any rate, somehow, the natural working of some natural law.

Red Snow was regarded with something of superstition from the period of its discovery down to recent times, when its true character was revealed. Various speculations had been indulged in, even by the scien-* Cohn on *Riccularia fluitans*, in “Hedwigia,” xvii. (1878), p. 1.
scientific, as to whether it was a lichen, or a fungus, or even an infusorial animal. Finally it was determined to be a fresh-water alga, to which the name now applied is *Chlamydococcus nivalis*.

It is believed that De Saussure first noticed the red snow, in 1760, on Mount Breven, in Switzerland, and subsequently so frequently amongst the Alps, that he was surprised that it should have escaped notice by all previous travellers. Ramond found it in the Pyrenees, and Sommerfeldt in Norway. In 1818 an Italian journal contains an account of the fall of red snow in the Italian Alps and on the Apennines. In March, 1808, the whole country around Cadore, Belluno, and Feltri was covered in one night, to the depth of twenty centimetres, it is said, with a rose-coloured snow. A pure white snow fell before and afterwards, so that the coloured snow formed an intermediate stratum. A like phenomenon occurred at the same time on the mountains of Veltelin, Brescia, Krain, and Tyrol. A similar one occurred at Tolmezzo, in the Friaul, between the 5th and 6th of March, 1803, and a more remarkable one still, in the night, between the 14th and 15th of March, 1813, in Calabria, Abruzzo, Tuscany, and Bologna, consequently along the whole chain of the Apennines.*

Captain Ross saw mountains in Baffin's Bay which were covered by red snow, eight miles long. The snow was found to penetrate in some places to a

* "Memoir on the Red Snow," by C. A. Agardh.
depth of ten or twelve feet, and seemed to have existed long in the same state.

The early opinion prevalent was that the red snow fell from the sky, that it invariably fell during the night, and of course nobody ever saw it fall.

Like other algae, moisture seems essential to its production, and hitherto this plant has not been found in places where it was debarred from this pabulum at some period of its growth. But once formed, it seems to possess the power of remaining stationary, and, perhaps, of reviving after an unlimited period. In the Arctic region it was discovered on snow, on rocks, on decayed mosses, and on the bare soil. In Scotland its locality is curious. The island of Lismore, in which it is found, is very low, ten miles in length by only one or two in breadth, and resting on a limestone rock, of a slate-blue colour. "It occurs," says Carmichael, "in abundance on the borders of the lakes of Lismore, spreading over the decayed reeds, leaves, etc., at the water's edge, but in greater perfection on the calcareous rocks within the reach of occasional inundation; and, what is rather remarkable, it seems to thrive equally well, whether immersed or exposed to the dry atmosphere. It is to be found, more or less, at all seasons of the year."

Dr. Greville examined some of the Lismore specimens and some from the Arctic regions, with the following results: "I had them immersed in water for a period of three weeks, but did not succeed in tracing
any appearance that was not developed equally well in the course of a few hours. In every instance I found no difficulty in detecting a gelatinous substratum, various in thickness (sometimes exceeding the diameter of the globules), colourless, diffuse, without any defined border. Upon this gelatine rests a vast number of minute globules, the colour of fine garnets, exactly spherical, nearly opaque, yet very brilliant, for the most part nearly equal in size; the smaller ones generally surrounded with a white pellucid limb, like the capsules of Ceramium roseum; and this limb gradually becoming less as the globules enlarge, at last entirely disappearing. In the full-sized globules, a favourable light shows the existence of internal granules, which make the surface to appear reticulated. When mature they burst, and the internal granules escape, to the number of six or eight, or more, and the membrane only of the globule is left behind, buoyant and colourless. The granules are globose, and escape from the globules one by one, or by several at once, adhering together, though I never could observe the least voluntary motion among any of these bodies.” *

We need not enter into details in this place of the true character and metamorphoses of the red snow alga, which probably does not differ in all essential particulars from the life history of that allied species

NOTABLE PHENOMENA.

which was so long known under the name of Pro-
tococcus pluvialis, but now denominated Chlamydo-
ococcus pluvialis. An exhaustive memoir has been published of this latter, by Professor Cohn, and finds notice in our chapter on "Alternation of generations." There are, indeed, some algologists who contend that the red snow is, at most, only a variety of the more common Chlamydococcus pluvialis, and, if that be the case, what is true of the one, will, as far as physiological details are concerned, be true of the other. In the active stages of these species the causes will be recognized wherefore some writers, in the past, have been doubtful whether "red snow" was an alga or an infusorian. Even Agardh did not seem to be fully convinced on this point, which now scarcely admits of doubt.

In the year 1878, Brun noticed on the sacred mountain near the city of Ouessin, in Morocco, a so-called "rain of blood," which he found to result from a quantity of minute shining flakes, which adhered closely to the rocks, and presented an extraordinary resemblance to drops of blood. These were found to be a young undeveloped condition of Chlamydococcus pluvialis, mixed with organic remains and fine sand. He suggested that they had been brought by a strong south-west wind from the Sahara, where the Chlamy-
dococcus is assumed to be extremely abundant.*

Of the occurrence of red snow in Hertfordshire little

can be said, except to refer to the communication in which the circumstance is narrated.* It is not impossible that it should occur in such a locality, but there is a little confusion in the narrative. What is meant by Protococcus is not sufficiently clear, and the inference that some condition of Euglena caused the red appearance serves in no way to elucidate the mystery.

Gory Dew.—This is one of the names which has been applied to an alga, by no means uncommon, to which the superstitious in past ages ascribed singular attributes. Drayton writes that "In the plain, near Hastings, where the Norman William, after his victory, found King Harold slain, he built Battle Abbey, which at last, as divers other monasteries, grew to a town enough populous. Thereabout is a place which, after rain, always looks red, which some have attributed to a very bloody sweat of the earth, as crying to Heaven for vengeance of so great a slaughter." The substance itself is common in the lower part of damp walls, in cellars, dairies, and outhouses, on the ground, gravel walks, and hard-trodden paths, and is most conspicuous after rain. It forms broad patches of a deep blood-red or purple colour, with a shining surface, as if blood or red wine had been poured upon the ground. Examined by the microscope, it consists of an agglomeration of minute globose cells, filled with granular matter. Its

present name, for it has had many, is Porphyridium cruentum (Fig. 7).

The appearance of this organism has doubtless contributed at times to verify the vulgar belief in the occurrence of showers of blood, in the form of hail, snow, or dew. In dry weather it loses its bright colour and becomes blackened, but when moist it certainly resembles coagulated blood, which often appears in patches on the floor of wet conservatories and greenhouses. How many monkish legends may have been indebted to this phenomenon for support it is impossible to say, for it lent itself readily to such purposes, and must often have caused the superstitious to shudder, being ignorant of its real nature. In this respect its honours may be divided with the next species.

Blood Rain.—This organism forms blood-red spots on bread, rice, potatoes, and even on meat, and at the time of Ehrenberg was held to be a minute animal, or rather a colony of minute animals. Afterwards it came to be regarded as an alga, and bore the name of Palmella prodigiosa. More recently still it had been relegated to that mysterious little group of obscure fungi, called the Schizomycetes, where it rests at present under the name of Micrococcus prodigiosus. Perhaps, for the latter reason, no mention should have been made of it here, but as opinions have been, and possibly still are, divided as to its claims to be considered an alga or a fungus, a brief reference is
advisable. About 1886 an epidemic on the Continent was traced to this source. Pieces of cooked meat presented a singular carmine-red coloration, and stained vividly the fingers or linen with which they came in contact. These phenomena prevailed regularly for a period of three months. Food cooked overnight was found the next morning covered with red patches, and it then underwent rapid alteration. Coincident with a sudden and considerable fall in the temperature, the epidemic ceased, and has not reappeared.* Berkeley has also stated that "In the hot days of July, 1853, provisions which were cooked in the evening were in some cases the next morning covered with this production. The only instance of similarly rapid development is that of yeast globules, and it is there probably that we must look for the true solution of the question as to its real nature." And again: "The rapidity with which it spreads over meat, boiled vegetables, or even decaying agarics is quite astonishing, making them appear as if spotted with arterial blood; and what increases the illusion is, that there are little detached specks, exactly as if they had been squirted in jets from a small artery. The particles of which the substance is composed have an active molecular motion, but the morphosis of the production has not yet been properly observed, and till that is the case it will be impossible to assign its place rightly in the vegetable world. Its resemblance to the

gelatinous specks which occur on mouldy paste, or raw meat in an incipient state of decomposition, satisfy me that it is not properly an alga.”* Mr. H. O. Stephens, on the other hand, contends that it is an algoid production. After narrating its history,† he says, “I observed at table the under surface of a half-round of boiled salt beef, cooked the day before, to be specked with several bright carmine-coloured spots, as if the dish in which the meat was placed had contained minute portions of red-currant jelly. On examination the next day, the spots had spread into patches of a vivid carmine-red stratum of two or more inches in length.

“With a simple lens the plant appears to consist of a gelatinous substratum of a paler red, bearing an upper layer of a vivid red hue, having an uneven or papillate surface. The microscope shows this stratum to consist of generally globose cells immersed in or connected by mucilaginous or gelatinous matter. The cells vary in size, and contain red endochrome. As far as I can observe, they consist of a single cell-membrane, and contain a nucleus. Treated with sulpho-iodine, they become blue. In my judgment, this plant is a Palmella closely allied to P. cruenta, but certainly distinct, the cells or granules of the latter differing from it not only in their colour but size.” The memoir also contains observations on the great vitality of this

† Annals and Magazine of Natural History (1853), p. 409.
species, and other subjects connected therewith, to which the student is referred.

Ehrenberg remarked of another alga, which is terrestrial in its habits, and known as *Sphaeroplea annulina*, that it covers large tracts about Berlin with a red coating, and hence may have given rise to traditions of "blood rain." At Breslau, where Professor Cohn saw it at the end of October, it occurred in a potato field which had been laid under water by the overflow of the Oder. It covered the field on the retreat of the water in an almost uninterrupted felt, of a beautiful red-lead or vermilion colour on the smooth upper surface, and green on the under side. The red colour depended on the spores with which the filaments were completely filled up. This, however, is a less likely source of the traditions of "blood rain" than the more minute species which appear as stains, or blood-red blotches, upon the ground and other objects.
CHAPTER XIII.

THE DUAL HYPOTHESIS.

There is one hypothesis, which has made some stir in the world, in which green algae are implicated, and it would be expected that a work of this kind should not pass it over in absolute silence. It will not be necessary to recapitulate the voluminous controversy which has now being going on for some years, but simply to state the theory, and the objections urged against it. Shortly expressed, the contention is that the large group of vegetable organisms which have been known as lichens are not independent or autonomous plants at all, but merely a combination of fungus and alga. This theory originated with Schwendener, possibly based on a suggestion of De Bary, and has been kept alive by the Germans down to the present.

The paragraph which is believed to contain, in a compressed form, the whole contention of the theorists, is to the following effect:—"As the result of my researches, all these growths (lichens) are not simple plants, not individuals, in the ordinary sense of the
word; they are rather colonies, which consist of hundreds and thousands of individuals, of which, however, one alone plays the master, whilst the rest in perpetual captivity prepare the nutriment for themselves and their master. This master is a fungus, of the class Ascomycetes, a parasite which is accustomed to live upon other's work; its slaves are green algæ, which it has sought out, or indeed caught hold of, and compelled into its service. It surrounds them, as a spider its prey, with a fibrous net of narrow meshes, which is gradually converted into an impene-trable covering; but whilst the spider sucks its prey and leaves it dead, the fungus incites the algæ found in its net to more rapid activity, nay, to more vigorous increase."* It has never been challenged, that the following is an accurate statement of the case. The two great points sought to be established are these: that what we call lichens are compound organisms, not simple, independent vegetable entities; and that this compound organism consists of unicellular algæ, with a fungus parasitic upon them. The coloured gonidia which are found in the substance, or thallus, of lichens are the supposed algæ, and the cellular structure, which surrounds, encloses, and imprisons the gonidia, is the parasitic fungus, which is parasitic on something infinitely smaller than itself, and which is entirely and absolutely isolated from all external

* Schwendener, "Die Algentypen der Flechtengonidien" (1869), p. 3.
influences. The theorists therefore maintain that lichens are identical with fungi, with the addition of certain extraneous bodies, called "gonidia," which are truly microscopic algae.

Whether lichens are autonomous plants, or whether, independently of their gonidia, they are identical with fungi, are not questions to be discussed here, and we have elsewhere given our conclusions on these points.* All that we are concerned to inquire is, whether the so-called "gonidia" of lichens are green algae. A very important result was obtained by Dr. Minks, when he confirmed and established the fact that the gonidia decidedly have their origin in the hypha and cortical cells, but he proves from his experiments—which have been checked by other cryptogamists—that the microgonidia, which are transformed into gonidia, exist in the hypha, rhizines, cortical cells, paraphyses, young thecae, and even in the spores and spermatia, that is to say, in all the vegetative and reproductive cells. The transformation of the microgonidia into gonidia can easily be seen under the thin cortical layer, and in those parts of the bark which are contiguous to the medulla.

Are gonidia a part of the lichen-structure, or are they appropriated green algae? This is the only point in which the hypothesis enters into the scope of our work. It is well known that the thalli of lichens enclose within them peculiar cellules, forming a sub-

* "The Dual Lichen Hypothesis" in Grevillea (March, 1879).
cortical layer, which are subglobose, of a greenish colour, and to these the name of gonidia has been given. They frequently burst through, and appear on the surface in the form of powdery masses. The lichenologist believes, and as he thinks upon good grounds, that they form part of the plant itself. One says, “They may be regarded as intermediate in function between the vegetative and reproductive cell, assuming the offices and partaking of the characters of both.” Tulasne considered them to be parts of the lichen structure, performing important functions. The theorists contend, on the other hand, that they are no part of the plant, but that they are a form of alga, upon which the residue of the lichen is parasitic.

It is argued that they are free cells, resembling in size, form, and colour certain low forms of unicellular algae, and hence, as they are out of place in lichens, they must be unicellular algae. Any one who has had any experience amongst the low forms of vegetable life, in which the organism consists of a single cell, are exceedingly well aware that it is almost an impossibility, from the observation of these cells, to arrive at any satisfactory conclusion as to what they are, and what their ultimate development may be. Let them compare, if they please, what are known to be the earliest stages of mosses and algae with the gonidia of lichens, and draw up characteristic diagnoses, if they can. All are globose cells, containing a greenish protoplasm, and about equal in size.
By what occult power can the theorists distinguish that which, it is admitted, they cannot describe? The only safe method by which these low forms can be determined is by watching their development. In their simple condition of cells, they are no more than mere buds, the ultimate form of which only the rash or foolish would predicate.

If the gonidia of lichens are true algae, it is insufficient to state that they so closely resemble algae that they might be mistaken for such; there must be some undoubted evidence produced that they are algae in fact, and not in appearance.

But if, on the contrary, the experience of practical lichenologists is all in favour of the opinion that the gonidia are truly parts of the lichen structure, that they belong essentially to the lichen, all speculation should be at an end. Dr. Nylander, the prince of lichenologists, has written, "I have adduced that the gonidia and gonimia of lichens constitute a normal organic system necessary, and of the greatest physiological importance, so that around them we behold the growing (or vegetative) life chiefly promoted and active." And again, he says, "The absurdity of such an hypothesis is evident from the very consideration that it cannot be the case that an organ (gonidia) should at the same time be a parasite on the body of which it exercises vital functions."

It can be clearly demonstrated that the gonidia are developed within the substance of the lichen itself in
a determinate and uniform manner, that, instead of being altogether foreign to the lichen, they are generated within it, and hence (according to the hypothesis) the parasite produces from its own substance the host upon which it is parasitic.

It has been disputed whether the microgonidia of Dr. Minks have anything whatever to do with the production of gonidia, and it may be added that whether true or false makes no difference to the ultimate conclusion whether the gonidia themselves are an integral part of lichen structure or not.

There is, undoubtedly, a remarkable coincidence in the structure of a Nostoc (Fig. 92) amongst algae, and a Collema amongst lichens. This resemblance probably first led to the insinuation of relationship. In its early days the theorists got but little further than Nostoc and Collema, but they soon became reckless. No one would attempt to deny that the Collemaceae are a sort of outside group of lichens; they are classified by themselves, and tacked on as an appendage to the true lichens, as if they were a kind of pseudo-lichen. Perhaps with less prejudice and less of theory a more disinterested inquiry into any relationship between Nostoc and Collema would have resulted in far greater advantage to science than all the volumes of Schwendenerian controversy.

It is a common mistake, repeated over and over again, under varied conditions and circumstances, to confound analogy with affinity; and even to assume
identity where there is only analogy. "In a scientific inquiry a fallacy, great or small, is always of importance, and is sure to be, in the long run, constantly productive of mischievous, if not fatal results." It is undoubtedly a fallacy to assume that things which are only analogous are identical, as if there were no real difference between analogy and identity. In the present instance no more decided evidence need be given than in the case of the gonidia. It has been deemed unnecessary to demonstrate that they are algae, but simply on the faith of their analogy has identity been assumed. The interests of truth demand that fallacies should be encountered, and not accepted on the faith of any authority whatever, be that authority ever so great, or ever so highly esteemed amongst men.

Text-books are teaching, and will be teaching, one after another, that this hallucination and some others are accepted—in Germany—and therefore must be true. It is often the case that persons are most positive about the very things of which they know the least. We may ourselves be in error, but in this case we err in company with all the most celebrated lichenologists of the day—Nylander, Krempelhuber, Th. Fries, Koerber, Archangeli, Crombie, Weddel, Franck, and Müller. Hence this chapter is scarcely necessary, there being no true green alga concerned in the ordinary life-history of lichens; or, if so concerned, the fact has not yet been satisfactorily demonstrated.
CHAPTER XIV

CLASSIFICATION.

It is a well-known practice, in all branches of natural history, to group together all the various objects which constitute each separate branch, in a systematic manner for convenience of study, and in order that the different objects, whether called species or varieties, may be quoted, or referred to under some distinctive appellation, so that something like accuracy may be arrived at. Whatever this classification, or arrangement, may be, it is to a greater or less extent artificial, and is only a means to an end. However perfect it may seem to be when constructed, or modified, depends upon its accordance with the total of knowledge available at the time of construction, but it cannot long remain perfect in detail, because knowledge is progressive, whilst systems are fixed, and are constantly in need of modification in order to keep pace with the accumulation of fact. There are some who affect to despise system or classification altogether, quite forgetting that there could be no science without it, and there are others, probably, who think that
science consists solely in classification. As it is folly to think of science without system, so is it equally absurd to mistake classification for science, whereas it is simply a necessary appendage to science.

Without, therefore, desiring to claim for classification a position greater than its merits, we would briefly indicate some of the features of the classification of algae, and especially of the fresh-water species, in order that the arrangement hereafter followed may be somewhat intelligible. It will serve no useful purpose to refer back to old and crude methods, antecedent to that adopted by Professor Harvey in "Phycologia Britannica," to which that of Lindley's "Vegetable Kingdom" was similar, with an alteration of names. The principal divisions of the whole mass of algae were four: Diatomaceæ, with a siliceous skeleton, and three other groups, viz. the Chlorosperms, with the seeds or spores green; Rhodosperms, with the spores red; and Melanosperms, with the spores olive. This purely artificial method was employed for a long time, even whilst it was acknowledged to be unsatisfactory, because it appeared to be simple and easy, and practically answered the purpose. Lindley proposed, in addition to the Diatomaceæ, the three orders of Con fvaceæ, almost equal to the Chlorosperms; the Fucaceæ, nearly equivalent to the Melanosperms and the Ceramiaceæ, being about the same as the Rhodosperms.

Strong objections were sometimes urged against the
method adopted by Professor Harvey, and these found expression in Berkeley’s “Introduction to Cryptogamic Botany,” in the following words:—“The difficulties are the most glaring in the Chlorosperms, which comprise a considerable number of species which have not green fruit in any stage of growth; or, at least, not as a primitive stage, for the red spores of the Rhodosperms sometimes become green in decay. The contrary effect takes place in some Chlorosperms, where the green assumes a dark red, but not rosy tinge, probably by the same process which changes the natural green of leaves into autumnal red.” And, after some other objections, too technical for reference here, he proceeds to adopt the method proposed by Professor Harvey.

It was this same arrangement, as far as the primary groups are concerned, with one modification, which was adopted in Cooke’s “Fresh-Water Algæ,” and consequently we have retained it here. The modification was the division into two groups of the green algæ, as Chlorophyllumophyceæ, with the contents chlorophyl green; and Phycochromophyceæ with the contents bluish green. There is not the least doubt that such an arrangement as we have adopted will soon have to be abandoned for something better, but this will not alter the arrangement practically a great deal, except as regards the primary groups.

Some most elaborate schemes have been proposed—on paper—for the reconstruction of the classification of algæ, but, like paper constitutions, not a few of
them are impracticable. When those who believe in systems, as the *ultima thule*, have discussed and decided upon the best and most philosophical method to replace the old ones, and the new is found to be useful, and practicable to facilitate study, it will not then be very difficult to rearrange the smaller groups under some other system, like the shuffling of a pack of cards.

Practically the bulk of the fresh-water species are green algae. The few *Rhodosperms* may be called by that name, or, if preferable, *Florideae*. It matters little; the names will be altered, but the things they represent will remain the same. Whether the chlorophyl-green algae are really the highest, is of but little importance, except perhaps to rabid evolutionists. They may stand at the top, or the bottom, of any scheme, and yet their position be of no practical consequence. The classification of the green algae will, doubtless, be much simplified and improved when all the polymorphic forms are run in, and instead of our meeting with one stage, or condition, under one name, a more complex stage under another, and a still more developed condition under a third or a fourth, we shall have all the phases of the life history, well determined and arranged, under a single name.

Without attempting to dogmatize upon the necessity or advisability of excluding certain forms of algae from the green series, and calling them Protophytes, this is an article of faith with some constructors of paper
systems, and it would be simply heresy in their eyes to doubt its wisdom. If it simplifies classification, that will certainly be a point in its favour, but multiplication of obscure, or ill-defined, or even of too finely drawn distinctions, often leads to confusion rather than to clearness.

The most pretentious of philosophical systems has of late been fairly placed before the public, and the principles on which it is based have thus been laid down by one of its authors. Too little importance has, he considers, hitherto been attached to degeneration or retrogression, which may be exhibited in the partial or complete suppression of either the reproductive or the vegetative organs. He traces all the various forms of vegetable life to three lines of descent, represented by three distinct kinds of cell-contents—colourless, blue green, and pure green. The first appears to originate in the Bacteria or Schizomycetes, from which are derived the whole group of fungi. The second primordial type consists of unicellular organisms, in which the cell-contents are composed of a pale, watery, blue-green endochrome, diffused through the protoplasm, without distinct chlorophyll grains, starch grains, or nucleus—the Chroococccaceæ, the simplest form of the Phycochromaceæ, or Cyanophyceæ, which attain their highest development in the Nostochineæ, including the Oscilariaceæ, Rivulariaceæ, Scytonemaceæ, and Nostocaceæ. To them are probably related the Diatomaceæ, which the author regards as
a simple form of life, probably not nearly connected with the Conjugatæ.

The third series, or Chlorophyllumophyceæ, is the only one which has developed into the higher forms of vegetable life. It is characterized from the outset by the cells possessing a nucleus, starch grains, pure chlorophyl, and, in certain states, a true cell-wall of cellulose. The lowest family, the Protococcaceæ, exhibit further development in two directions—the perfection and differentiation of the individual cells, and the association of cells into colonies, or cænobes. The latter tendency leads to the Sorastææ, Pandorineæ, and finally to the Volvocineæ. The further differentiation of the individual cell has advanced one stage in the Eremobioæ or Characiaceæ, from which are derived the Multinucleateæ, comprising the Siphonocladaeæ and Siphioneæ. The striving after a higher development by the elaboration of a single cell culminates in Vaucheria, or in such forms as Acetabularia. Cell-division is already well displayed in the Confervoideæ isogamæ, including the Chroolepidæ, Ulotrichaceæ, Conservaceæ, and Pithophoraceæ. From them evolution appears to have taken place in three different lines:—(1) The Conjugatæ, including the Zygmemaceæ, Mesocarpaceæ, and Desmidieæ, which evidently came to an abrupt conclusion; (2) the Phæosporeæ, which led through the Cutleriaceæ, and Dictyotææ, to the Fucaceæ, the highest type of "oogamous" reproduction, consisting in the impregnation of a com-
paratively large oosphere by a number of minute antherozoids; the Syngeneticæ being regarded as a retrogressive offshoot from the Phæosporeæ; and (3) the Confervoidæ heterogamæ, including the Sphaeropleaceæ, Ædogniaceæ, and Coleochætaceæ, from which latter family the Pediastreæ are probably derived by retrogression. The Coleochætaceæ lead up directly to the highest type of structure attained by Thallophytes, the Florideæ, from the highest form of which we have probably several retrogressive branches, viz. the Nemalieæ, the Lemaneaceæ, and the Bangiaceæ. The author suggests that the Ulvaceæ may possibly be derived from the Bangiaceæ by further retrogression.*

After this lucid (?) explanation of a philosophical system, presumably written by the author himself, it is hardly assuming too much that our readers will be satisfied, for the present at least, with a less philosophical and evolutionary method, and permit us to proceed with our enumeration upon antique lines.

ARRANGEMENT OF THE
BRITISH SPECIES OF FRESH-WATER ALGÆ.

The old artificial arrangement of Algæ comprised five classes—

I. CHLOROPHYLLOPHYCEÆ. Contents chlorophyl green.
II. PHYCOCHROMOPHYCEÆ. Contents bluish green.
III. MELANOPHYCEÆ. Contents olive or blackish.
IV. RHODOPHYCEÆ. Contents red or violet.
V. DIATOMOPHYCEÆ. With a siliceous skeleton.
Classes III. and V. may be excluded here.

Class I. CHLOROPHYLLOPHYCEÆ.
Cell-contents mostly chlorophyl green, sometimes crimson or brown.

ORDER I. COCCOPHYCEÆ.
Unicellular. Cells single, or associated in families, tegument involute or naked, destitute of branches.
Family I. Palmellaceae.

Cells solitary, or in families, vegetating by cell-division, propagating by active gonidia.

Genus 1. Eremosphæra. De Bary. (1858.)

Cells single, rather large, free swimming, spherical, with a hyaline border. Cell-contents green. Multiplication by division into 2 or 4 or more sister cells (Fig. 1).


Cells globose, large, of a beautiful grass green.
In boggy ditches.

Genus 2. Pleurococcus. Meneg. (1842.)

Cells gregarious, globose, or angular; single or associated in small families. Cell-contents green, or oily red. Multiplication by division in alternate directions. Propagation by gonidia. Aquatic or aerial (Fig. 2).

* Species green.


Cells variable, simple, binate, or quaternate, or 32, associated in families, aggregated in a crustaceous, powdery, bright green stratum. Cells 4–6μ; families 18μ and more.
On trunks of trees, moist walls, etc. Common everywhere.


Cells single, or 2–4, associated (64) in families; deep green, in a greenish rather gelatinous stratum. Cell-membrane thick. Cells 7–13μ diam.
On stems and leaves of aquatic plants.
4. Pleurocococcus mucusus. (Rabh.) Cooke, Algæ, 4, t. 2, f. 3.

Cells very small, variable, single, and 4–16 associated in families, globose, scattered, or aggregated in a gelatinous stratum. Cell-membrane very thin, hyaline. Cells $2\frac{1}{2}$–3μ diam.

On naked ground.


On human hair used as “chignons.” (A doubtful species.)

** Species red or brownish.

6. Pleurocococcus miniatus. (Kutz.) Cooke, Algæ, 6, t. 2, f. 5.

Cells variable, globose, usually single, rarely 2–4 in a family, seated on a broadly effused red stratum. Cell-membrane hyaline; contents oleaginous, orange. Cells $3\frac{1}{2}$–15μ diam.

On the walls of conservatories.


In ditches.

8. Pleurocococcus bituminosus. (Bory.) Kutz. Tab. t. f. 5.


On cellar walls.


Cells globose or oblong, either single, or 2–4–8 associated in globose families. Common and special integru-
ments gelatinous, lamellose. Division in alternate directions. Propagation by zoogonidia (Fig. 4).

* Species more or less green.


Fixed to submerged plants.

10. Glæocystis vesiculosa. (Nög.) Cooke, Algae, 7, t 2, f. 2.

Thallus gelatinous, green; cells small, globose, 6μ, and more, associated in families. Cell-membrane hyaline, lamellose; contents green. Cells 4½–7½μ; families 36μ diam.

On wood and stones in stagnant water.

11. Glæocystis rupestris. (Lyngb.) Cooke, Algae, 7, t. 8, f. 1.

Thallus more or less expanded, dirty green, gelatinous; cells globose, associated in families. Cell-membrane distinctly lamellose; contents green. Sporangia globose, containing from 4–12 gonidia. Cells 3½–5μ; families 60μ diam.

On rocks, moist walls, and damp earth.

12. Glæocystis botryoides. (Kutz.) Cooke, Algae, 8, t. 3, f. 3.

Thallus gelatinous, green; cells minute, globose or oblong, in small families. Cell-membrane indistinctly lamellose; contents green. Cells 2–4μ; families 10–18μ diam.

On submerged or constantly wet wood.

** Species fresh coloured, becoming reddish.


Thallus crustaceous, horny when dry, about a line thick, flesh colour; cells small, spherical, 2–4–8 in families. Cell-membrane very broad, distinctly concentrically
lamellose; contents becoming yellowish. Cells $3\frac{1}{2}-5\mu$; families 18–22$\mu$ diam.
On rocks constantly wet.

Thallus broadly expanded, gelatinous, firm, yellow brown; cells globose or oblong. Contents brownish green or brown; cell-membrane lamellose. Cells 8–13$\mu$ diam.
On chalk cliffs, about high-water mark, etc.

Genus 4. UROCOCCUS. Hassall. (1845.)
Cells large, globose or oblong; reddish or blood red; tegument thick, gelatinous, concentrically lamellose. Stem thick, gelatinous, often ringed, or annulate (Fig. 5).

* Stem annulate.

15. Urocoecus Hookerianus. (Hass.) Cooke, Algo, 9, t. 4, f. 2.
Cells globose or elliptic, variable, blood red; stem more or less elongated, often divided, densely ringed. Cells 13–60$\mu$ diam.
On chalk cliffs.

16. Urocoecus insignis. (Hass.) Cooke, Algo, 9, t. 4, f. 2.
Cells large, globose, blood red; stem abbreviated, remotely annulate.
On rocks.

** Stem exannulate.

17. Urocoecus Allmanni. (Hass.) Cooke, Algo, 9, t. 4, f. 2.
Cells elliptical, blood red; stem short, rather club-shaped, colourless, smooth.
In springs at Knaresborough.

18. Urocoecus cryptophilus. (Hass.) Cooke, Algo, 9, t. f. 4.
Cells small, oval, rarely globose. Cell-membrane very large, confluent with the short ringless stem.
On stalactites lining a cavern.
INTRODUCTION TO FRESH-WATER ALGÆ.

Genus 5. SCHIZOCHLAMYS. Braun. (1849.)

Cells globose, single, or 2-4 associated in families. Cell-membrane lamellose, dividing in 2-4 equal parts, sometimes adhering. Division in one or two directions (Fig. 3).


Cells globose; contents green, granulose. Cells 10-13µ diam.
In peaty swamps, moor pools, and boggy ditches.

Genus 6. PALMELLA. Lyngb. (1819.)

Cells globose, oval or oblong, surrounded by a more or less thick integument, generally soon confluent into a firm or soft jelly; thallus shapeless. Division of the cells alternately in all directions (Fig. 6).

* Mostly green.


Thallus expanded, gelatinous, deformed, olivaceous green; cells large, nearly equal, pale green. Cell-membrane very thin. Cells 7-13µ diam.
On stones in streams.

21. Palmella hyalina. (Breb.) Cooke, Algæ, p. 11, t. 5, f. 3.

Thallus gelatinous, irregularly expanded, green; cells very minute, crowded. Cell-membrane very soon diffuent. Cells 1µ diam.
In stagnant water and bogs.

** Reddish or orange.

22. Palmella miniata, var. aequalis. (Näg.) Cooke, Algæ, p. 12, t. 5, f. 2.

Thallus expanded, soft, brick red; cells nearly equal. Cell-membrane somewhat thick, colourless, indistinctly striate; contents orange, sometimes greenish. Cells 12-14µ diam.
On wet rocks, moist ground, etc.
22*. *Palmella prodigiosa.* (Mont.) Cooke, *Algæ,* 12, t. 5, f. 5.

Is claimed as a Schizomycete (Fungus). See Grove, *Synop.* p. 7, as *Micrococcus prodigiosus.*

**Genus 7. PORPHYRIDIUM.** Näg. (1849.)

Thallus between gelatinous and membranaceous, somewhat incrusting, composed of globose or many-sided cells. Multiplication by division in all directions (Fig. 7).


Thallus dark purplish red, gelatinous; cells angular or rounded, 7–9μ diam.
On naked ground, moist walls, etc.

**Genus 8. BOTRYDINA.** Breb. (1839.)

Cells oblong or rounded, involved in a very thick, gelatinous integument, in large families, often very numerous, enclosed in a mother-cell, which constitutes a subglobose thallus (Fig. 19).


Thallus minute, rarely larger than the head of a pin, globose, green. Thallus \( \frac{1}{10} \) to \( \frac{1}{10} \) mm. ; cells 2–4μ.
On moist ground, trunks, moss, etc.

**Genus 9. PALMODICTYON.** Kutz. (1845.)

Cells oval or globose, with a very thick gelatinous integument, united into a filiform thallus, which anastomoses in various ways. Cell-division simple or double. Propagation by zoogonidia (Fig. 11).


Thallus mucous, irregularly reticulate, thickness of a hair, greenish; cells biserial, with a thick membrane. Cells, without membrane, \( 7\frac{1}{2}–9\mu \); with membrane, 25–40μ.
In ditches, canals, etc., attached to twigs, etc.
INTRODUCTION TO FRESH-WATER ALGÆ.

Genus 10. TETRASPORA. Link. (1810.)

Thallus gelatinous, membranous or submembranous, at first a short sac, afterwards expanded; cells globose or angular, more or less distant, associated in a single stratum into large families. Cell-membrane thick, rapidly diffluent. Division in two directions (Fig. 8).

26. Tetraspora bullosa. (Ag.) Cooke, Algæ, p. 16, t. 6, f. 7.

Thallus membranaceous, saccate, obovate, an inch to a palm long, dark green, more or less warty; cells nearly spherical, geminate, or quaternate, crowded. Cells 8–12\(\mu\) diam.

In stagnant pools and ditches of fresh water.

27. Tetraspora gelatinosa. (Vauch.) Cooke, Algæ, 16, t. 6, f. 2.

Thallus vesiculose, clavate, gelatinous, unequally expanded, and irregularly torn, pallid, sometimes dirty green, often incrusted with lime; cells variable, globose, single or geminate, or quaternate, and somewhat crowded; contents green. Cells 3–4\(\mu\) diam.

In pools and ditches.

28. Tetraspora lubrica. (Roth.) Cooke, Algæ, 6, t. 6, f. 3.

Thallus elongated, tubular, erect, an inch to a palm long, 1–4 lines thick, splitting, sinuous, between gelatinous and membranous, yellow green; cells globose, green. Cell-membrane very thin. Cells 8–10\(\mu\) diam.

In ditches.

29. Tetraspora flava. (Hass.) Cooke, Algæ, t. 6, f. 4.

Thallus yellow when dry; cells small, quaternate.

In rocky rivulets.

Genus 11. BOTRYOCOCCUS. Kutz. (1849.)

Thallus botryoid (or like a bunch of grapes), irregularly lobed, mucous, involved in a thin membrane; cells ovoid
or elliptic, united in families, densely packed in a thin integument (Fig. 10).

30. Botryococcus Braunii. (Kutz.) Cooke, Algæ, 17, t. 7, f. 2.

Small, free swimming, green, at length becoming pallid, or reddish brown. Cells 10–12μ diam.

In moor pools.

Genus 12. APIOCYSTIS. Näg. (1849.)

Thallus small, vesicular, fixed by a stem-like base; cells globose, scattered, or sometimes 8, disposed in a circle. Cell-membrane thick, dissolving into gelatin, cells dividing alternately in all directions. Propagation by globose motile gonidia (Fig. 9).


Thallus pear-shaped, pallid green, the cavity filled up by gelatinous matter, in which are imbedded the gonidia, at first few, increasing in number with age as far as 1000. Frond 1/6–1 mm. high; cells 7½–11μ diam.

In fresh-water ditches.

Genus 13. RHAPHIDIUM. Kutz. (1845.)

Cells fusiform or cylindrical, generally cuspidate or acuminate at the ends, straight or curved, single, geminate, or fasciculately aggregate, rarely two laterally united at the end, other cells free. Cell-membrane thin; contents green. Division in one direction (Fig. 12).

32. Rhaphidium aciculare. (Braun.) Cooke, Algæ, 19, t. 8, f. 3.

Very slender, 15 to 20 times as long as broad, yellow green, often single, acicular, acutely cuspidate at each end, straight, or slightly curved, or somewhat lunate. 80μ long.

In pools.
33. *Rhaphidium falcatum*. (Corda.) Cooke, Algæ, 19, t. 8, f. 4.

Fusiform, slender, acutely cuspidate at each extremity, curved or semilunar, 4–16 congregated in fascicles. 30–40μ long.
In pools.

34. *Rhaphidium duplex*. (Kutz.) Cooke, Algæ, 20, t. 8, f. 5.

Fusiform, slender, slightly sigmoid, single, or 2–3–4 laterally connected at the poles, otherwise free. 30μ long.
In pools.

**Genus 14. DICTYOSPÆRIUM. Næg. (1849.)**

Cells elliptic, with a thick mucous investment, combined into free-swimming hollow globular families, one always at the end of delicate threads, which proceed from the central point of the family, becoming repeatedly branched towards the periphery. Division in all directions (Fig. 13).


Families aggregated in a globular or broadly elliptical figure; cells elliptic, very minute, about one-third as broad as long. Cells 4 × 7μ.
Amongst *Confervæ*.

36. *Dietyosphærium reniforme*. (Buln.) Cooke, Algæ, 21, t. 9, f. 2.

Families aggregated in an irregular form; cells uniform, nearly twice as broad as long. Cells 6–10μ × 10–20μ.
In mountain pools.

**Genus 15. DACTYLOCOCCUS. Nageli.**

Cells oblong or fusiform, free swimming, 2–8 in families at length separating. Division in one direction (Fig. 17).

Cells elliptic-oval, attenuated into a hyaline pedicle. Cell-contents green. Cells, $35\mu \times 16\mu$.
Parasitic on *Entomostraca*.

**Genus 16. Hormospora.** Breb. (1840.)

Thallus tubular, gelatinous, swimming free; cells oblong, green, arranged in simple longitudinal series (families) either remote or more or less united at the poles. Cell-membrane thick, contained within the broad gelatinous tube, which is either simple or branched (Fig. 14).

* Tubes simple.


Tubes intricate, more or less broad; cells twice as long as broad, broadly rounded at each end. Cell-membrane very thin. Cells $11-17\mu$; diameter of tube $43\mu$.
In boggy pools.


Tubes slimy, equal or undulate; cells ovate-oblong or fusiform, disposed transversely in a moniliform series; contents granular. Diameter of tube $75-120\mu$.
In bogs.

** Tubes branched.


Tubes broad, gelatinous, irregularly branched; cells oval or nearly cylindrical, obtuse at the ends, either remote or connected, twice as long as broad; contents green, with green plates radiating from the centre.
In brackish water, attached to *Cladophora*. 
Genus 17. **Hydrurus.** Agardh. (1824.)

Thallus adnate, gelatinous, tubular, elongated (2-4-12 inches long), sometimes variously divided; surface naked, or densely covered with delicate fibres, at times fasciculate. Cells globose, then elongated, arranged in longitudinal families. Cell-membrane thick, cells dividing in one direction. Propagation by agile gonidia (Fig. 15).

40. **Hydrurus penicellatus.** (Ag.) Cooke, *Algæ,* 25.

Thallus rather cartilaginous, olivaceous, of variable thickness, simple and naked below, divided above, and villous with dense fibrils; internal cells elliptical, or somewhat lanceolate. Cell-membrane thin, scarcely visible.

In rivulets.

var. **Ducluzeli.** (Rabh.) Cooke, *Algæ,* 25, t. 10, f. 4.

Thallus from an inch to a foot long, oftentimes sparingly branched, plumose with very dense fibrils. Cells 6–9 1/2 μ.

In Alpine rivulets, on stones, rocks, etc.

Genus 18. **Nephrocytium.** Nägeli. (1849.)

Cells oblong, kidney-shaped, 2-4-8-16 associated in free-swimming families, surrounded by an ample oval or kidney-shaped membrane (Fig. 16).

41. **Nephrocytium Agardhianum.** (Näg.) Cooke, *Algæ,* 26, t. 11, f. 1.

Cells pale green, 4 to 6 times as long as broad, spirally arranged, in families of 4-8 cells. Cell-membrane thin; length 2 to 3 times the breadth. Cells 35 × 10 μ.

In ditches, bogs, etc.

42. **Nephrocytium Nägeli.** (Grun.) Cooke, *Algæ,* 26, t. 11, f. 2.


In ditches, bogs, etc.
Genus 19. **Oocystis.** Nögelî. (1855.)

Cells oblong, chlorophyllous, either solitary or binate, quaternate, or octonate; contained at first within an ample mother-cell, at length free.


Mother-cell broadly elliptic, almost subglobose, large; family usually consisting of two cells. Mother-cell 60–70 \( \times \) 50–60\( \mu \).

In pools.


Species undescribed.

Genus 20. **Dimorphococcus.** Braun. (1849.)

Cells united in fours, on very short branches, dissimilar, the two intermediate contiguous oblique, obtuse ovate; the two lateral opposite and separate from each other, lunate; families free swimming, in botryoid clusters.

45. **Dimorphococcus lunatus.** (Br.) Cooke, *Algæ*, 27.

Green. Apices of the cells hyaline. Cells, longitudinal diam., 10–20\( \mu \).

In pools.

Genus 21. **Mischococcus.** Nögelî. (1849.)

Thallus dichotomously branched; cells globose, terminal, geminate or quaternate. Division of cells in one direction. Propagation by zoogonidia (Fig. 18).

46. **Mischococcus confervicola.** (Nög.) Cooke, *Algæ*, 28, t. 11, f. 4.

Cells globose, even, geminate, ternate, or quaternate, on the tips of the branches, bright green; stem hyaline, often swollen at the angles. Cells 5–9\( \mu \) diam.

Attached to filamentous algæ, in ditches.
Family II. Protococcaceae.

Unicellular, without terminal growth, or ramification. Single, or in families. Cells either indefinitely increasing in number (then forming families) or of a definite number (then forming a coenobium). Propagation by gonidia of two kinds—the one larger, macrogonidia; the other smaller, microgonidia.

Sub-Family 1. Protococceae.

Cells sphæroid, segregate; cell-membrane thin, hyaline, without integument, swimming free, or, when not growing in water, forming a thin pulverulent stratum. Contents at first green, or reddish.

Genus 22. Protococcus. Ag. (1824.)

Same as above. Propagation by mobile gonidia (Fig. 20).

47. Protococcus viridis. (Ag.) Cooke, Algæ, t. 12, f. 1.

Cells small, segregate, accumulated in a broadly expanded stratum, yellowish green, either pulverulent, or, in moist weather, somewhat gelatinous. Cells 2½–4μ. On the trunks of trees and damp walls.

Sub-Family 2. Chlorococcaceae.

Cells sphæroid, single and free, or more often accumulated in strata, or little clusters. Propagation by zoospores.

Genus 23. Chlorococcum. Fries. (1825.)

Cells subglobose, single or in clusters (Fig. 21).

† Tegument thin.
48. Chlorococcum humieolum. (Näg.) Cooke, Algæ, t. 12, f. 5.

Stratum effused, dark green, pulverulent; cells globose, variable in size, united in families, involved in a common tegument. Contents pale green, at length dark green. Cells 17μ.

On naked ground.

49. Chlorococcum frustulosum. (Carm.) Cooke, Algæ, t. 12, f. 2.

Thallus effused, pulverulent, green; cells globose, in families, involved in a broad hyaline envelope. Cells 4-7μ; families 40μ.

On moist rocks.

50. Chlorococcum murorum. (Grev.) Cooke, Algæ, t. 12, f. 4.

Thallus crustaceous, yellow green; cells subglobose, with a rather thick envelope. Cell-contents verdigris green. Cells 16-20μ × 10μ with membrane.

On walls.

†† Tegument thick.

51. Chlorococcum gigas. (Grun.) Cooke, Algæ, t. 12, f. 3

Stratum thin, green, mucous; cells globose, large, either single or associated in small families, always involved in a broad, distinctly lamellose hyaline tegument. Cells 12-17μ diam. without membrane.

In pools, on walls and glass windows.

Sub-Family 3. Polyedrieæ.

Cells single, segregate, free swimming, compressed, 3-4-8 angled; angles sometimes radially elongated, entire or bifid, oblong-elliptic laterally, rounded at the ends. Cell-membrane thin.


Characters the same as above for the sub-family.
INTRODUCTION TO FRESH-WATER ALGÆ.

A. Angles entire.


Cells irregularly pentahedrical (rarely hexahedrical), angles obtuse, sides concave. Maximum diameter, 64—75μ; minimum, 35—45μ.

In standing pools.

53. Polyedrium tetraedricum. (Nüg.) Cooke, Algæ, t. 13, f. 3.

Cells regularly tetrahedrical; angles obtuse, mucronate. Cells 15—30μ diam. (Fig. 29).

In pools.

B. Angles radiato-elongated.

54. Polyedrium longispinum. (Perty.) Cooke, Algæ, t. 13, f. 2.

Quadri-radiate, radii thin, elongated, scarcely thickened into a body in the centre. Length of arms 30—50μ (Fig. 23).

In pools.

C. Angles lobed.

55. Polyedrium enorme. (Ralfs.) Cooke, Algæ, t. 13, f. 4.

Cells irregularly tetrahedrical, angles produced, hyaline, deeply bilobed, sometimes repeatedly, with the lobes mucronate. Cells 25—40μ.

In pools.

Sub-Family 4. SCENEDESMEÆ.

Cells elliptic, oblong, or cylindrical; cell-membrane thin. Cells 2—4—16, joined in a series, or forming a coenobium. Propagation by division, whence arise gonidia, which unite into a coenobium within the mother-cell.

Genus 25. SCENEDESMS. Meyen. (1829).

Cells polymorphous, equal or unequal at the ends, often produced into a spine-like horn. Family of 2—8 oblong,
fusiform, or elliptic cells, in a single or double row; propagating by repeated segmentation, into one or more brood families (Fig. 24).

A. Cells unarmed.


Cells oblong or ovate, obtuse at the poles, 4–6–8 loosely connected in a simple series, or joined obliquely, 3 to 5 times as long as broad. Cells $5\frac{1}{2}$–7µ.

In boggy pools.


Cells fusiform or ovate-fusiform, acute at each extremity, 2–4–6–8 united in a series, either single and straight, or double and irregularly alternate; 3 to 6 times as long as broad. Cells 25–35 × 3µ.

In pools and boggy places.

*var. b. obliquus*. (Rabb.) Cooke, *Algæ*, t. 13, f. 6 c.

Cells elliptic, fusiform, arranged in two generally oblique series, the outer cell of each not in contact with any of those in the other series.

*var. c. dimorphus*. Cooke, *Algæ*, t. 13, f. 6 b.

Cells acute, 4–8 placed evenly in a single row, inner cells fusiform, outer lunate.


Cells fusiform, 2–4–8 joined in a single or double series, all somewhat curved, usually ventricose, cuspidate at each extremity, the apices bearing a hyaline globule. Cells 25–35 × 2µ.

B. Cells armed.


Cells oblong-cylindrical, extremities rounded, 2–4–8 narrowly united, in a single or double series, all straight;
outer cells armed at each extremity with a recurved spine. Cells $8\frac{1}{2}$–10 × 2μ.
In standing water.

Sub-Family 5. Hydodictyææ.

Individual cells oblong-cylindrical, united into a reticulated saccate cœnobium, some producing macrogonidia, which join themselves into a cœnobium within the mother-cell, others producing microgonidia, which are ciliate.


Characters the same as in the sub-family (Fig. 22).

60. Hydrodictyon utriculatum. (Roth.) Cooke, Algæ, t. 14, f. 1.

Size of the families (net) variable; also of the cells (forming the meshes) and the gonidia, according to circumstances.
In clear water.

Sub-Family 6. Ophiocytææ.

Cells cylindrical, at first short, then elongated, either variously curved and contorted, one or other pole attenuated into a thin, short stem, free swimming; or straight or more or less curved, collected in an umbel with a simple stem, or forming a composite umbel. Cell-contents green. Propagation by gonidia.

Genus 27. Ophiocytium. Näg. (1849.)

Cells cylindrical, short, then elongated, variously curved, sometimes circinate, attenuated at one extremity; free swimming. Propagation by division and formation of gonidia (Fig. 25).

Slender, pale green, often very long, filiform, variously curved, circinate, or more or less loosely spirally involved; stem short, spine-like, acute or truncate; contents homogeneous. Cells 5–7\(\frac{1}{2}\)μ diam.; length variable.

In pools, mixed with other algæ.

**Genus 28. SCIADIUM. Braun. (1855).**

Thallus (solitary) adnate, unicellular; cell elongated, cylindrical, straight, attenuated into a slender stem. Gonidia about 8, from division of cell-contents, at length protruding from the ruptured apex, retained at the mouth and extending in the form of an umbel, each individual becoming a cylindrical cell like the mother-cell. Process repeated to a third or fourth generation, forming a composite umbel. Ultimate cells producing zoogonidia (Fig. 26).


Umbellate. Cells straight (rarely falcate), obtuse at the apex; stem about as long as the diameter of the cells. Cells 3\(\frac{1}{2}\)–7μ diam.

Attached to confervoid algæ and aquatic plants.

**Sub-Family 7. PEDIASTREEÆ.**

Cœnobium discoid, plane.

**Genus 29. PEDIASTRUM. Meyen. (1829).**

Cœnobium plane, frond-like, discoid, or stellate, free swimming, formed of cells mostly in a single stratum, continuous, or with the cells here and there interrupted, perforate or clathrate. Cells polygonal, central entire,
those of periphery entire or two-lobed. Cell-contents green (Fig. 27).

**SECTION 3. DIACTININUM.**

Cells of periphery emarginate or bilobate, lobes entire.

63. *Pediastrum selenæa.* (Kutz.) Cooke, Algæ, t. 16, f. 9.

Coenobium orbicular, entire, formed of 8–16 (rarely 31) cells. Cells of periphery narrow, lunate, acutely lobed; cells of disc slightly excised, central one 5-angled; substance firm, rather thick. Coenobium 28–85μ diam.

In bogs, moor pools, etc.

64. *Pediastrum angulosum.* (Ehr.) Cooke, Algæ, t. 16, f. 10.

Coenobium orbicular, oblong, or subreniform, continuous, composed of 8–16–32–64 cells. Cells angular, those of the periphery truncate at the base and dilated upwards, notched in the middle; lobes obliquely truncate, outer angle shortly apiculate, inner one ending in a short horn. Central cells 5–6 angled, marked with a small transverse oblong pallid spot. Coenobium 12μ diam.; cells 19μ diam.

In bogs.

65. *Pediastrum Boryanum.* (Turp.) Cooke, Algæ, t. 16, f. 11.

Coenobium obicicular, oblong, or elliptic, continuous, bright green, composed of 4–8–16–32–64 (rarely 128) cells. Cells of periphery more or less deeply emarginate, or two-lobed; lobes horn-like, sometimes a little thickened. Central cells very closely concrete, 4–6 angled; membrane punctate. Cells 20μ transverse diam.

In boggy pools.

*var. B. granulatum.* (Kutz.) Cooke, Algæ, t. 16, f. 12.

Cells as in the preceding, but all the cells and the horns distinctly granulated.

In the same localities.

Cœnobium orbicular or oblong, continuous, deep green, sometimes bluish green, composed of 16–32 cells. Cells of periphery 2-lobed to the middle, lobes straight, produced into a truncate, bidentate horn. Central cells 4–5 angled, slightly repand in front.

In boggy pools.


Oval, regular periphery of 32 lunate cells with 2 divergent horns. Inner cells polygonal, in 2–4 rows. Cœnobium, with a gelatinous envelope, 90–160μ long; cells 6μ long.

In bog pools.


Cœnobium orbicular, bright green, continuous, smooth (?), composed of 16–32 cells. Cells of periphery 2-lobed, sinus narrow, lobes unequal, now and then constricted at the base, produced into an obtuse, rather thick horn. Central cells polygonal, repand in front.

In standing water.


Cells quaternate, closely joined in a circle, centre open, rarely closed; cells deeply 2-lobed, lobes ovate, produced into a long divergent, acuminate horn.

In pools.


Cœnobium orbicular, pierced with lacunæ, composed of as many as 64 cells. Cells of periphery loosely connected at the base, bilobed almost to the middle; lobes straight, produced into a hyaline horn. Central cells more or less quadrangular, emarginate in front, with 2 paler spots. Perfect cells 16–22μ transverse diam.

In pools.
INTRODUCTION TO FRESH-WATER ALGÆ.

var. b. **clathratum.** (Br.) Cooke, Algae, t. 17, f. 5.
Disc pierced with larger openings; central cells deeply notched and bilobate.

var. c. **brachylobum.** (Braun.) Cooke, Algae, t. 17, f. 6.
Cells larger, those of the periphery emarginate or triangularly notched, shortly 2-lobed; horns very short, truncate, or almost obsolete. Cells of the disc perforated with smaller openings.

SECTION 4. **TETRACTINUM.** Braun.

Cells of periphery emarginate or bilobate; lobes emarginate, bidentate, or bifid.

71. **Pediasstrum Ehrenbergii.** (Br.) Cooke, Algae, t. 18, f. 1 a, c.
Cenobium orbicular or oblong, of 8–16 cells, or quadrate, of 4 cells, wedge-shaped, deeply lobed and arranged in the form of a cross. Cells of periphery cuneate, truncate at the base, deeply bilobate; sinus narrow, lobes obliquely truncate, notched, interior angles twice as long, all acute, or shortly appendiculate. Central cells yellow-green, polygonal, one side repand or deeply notched.
In pools and boggy places. Not uncommon.

var. a. **truncatum.** (Braun.) Cooke, Algae, t. 18, f. 1 b.
Lobes truncate.

var. b. **excisum.** (Braun.) Cooke, Algae, t. 18, f. 1 d, e.
Lobes slightly notched, emarginate.

var. c. **cuspidatum.** (Braun.) Cooke, Algae, t. 18, f. 1 g, h.
Lobes deeply notched, evidently bidentate or bicuspidate.
In stagnant water, throughout Europe generally.

72. **Pediasstrum rotula.** (Ehr.) Cooke, Algae, t. 18, f. 2.
Cenobium orbicular or oblong, cells variable, 4–8–16–32, pierced with openings, bright green, even. Cells of
periphery truncate at the base, more or less dilated upwards, deeply bifid, sinus acute, lobes straight, narrow, bidentate, teeth erect or divergent, somewhat bent; cells of the centre usually polygonal, repand, or notched, containing a single paler spot.

In pools, etc., throughout Europe.

Sub-Family 8. Sorastreæ.

Cells polygonal, often shortly horned, associated in a hollow cænobium. Cell-membrane thin; cell-contents green. Propagation by gonidia, simultaneous or after division, united into a cænobium within the mother-cell, escaping by rupture of the membrane.


Cænobium globose, hollow within, formed of a single stratum of cells, reticulately pierced (Fig. 31).

73. Cælastrum sphæricum. (Näg.) Cooke, Algæ, t. 19, f. 2.

Cænobium globose or subglobose, composed of 4–8–16 or a larger number of cells, perforated, areolæ 3–4–5–6 angled. Cells rounded; outer angles somewhat conical, obtusely rounded at the apex; interstices 5–6 angled. Cænobium 4–8 mm. diam.; cells 21–23μ.

In boggy places.


Cells rounded on the exterior margin, each bearing a single truncate tubercular process.

In pools.

75. Cælastrum microsporum. (Näg.) Braun, Alg. Unic., p. 70.

Cells 8–16 or 32, exactly spherical, containing a single globule; interstices small. Cænobium 4 mm. diam.; cells 9μ diam.

In bogs and pools.
214 INTRODUCTION TO FRESH-WATER ALGÆ.

Genus 31. **Staurogenia. Kutz.**

Coenobium cubical, hollow within, formed of 4–8–16 quadrate or sub-quadrate cells. Propagation by quiescent gonidia, produced after the subdivision of the cell-contents (Fig. 28).

76. **Staurogenia rectangularis.** (Braun.) Cooke, Algæ, t. 18, f. 3.

Cells oblong-oval, 4–16–64, associated in tabular families, almost twice as long as broad; angles obtusely rounded. Cells $7\frac{1}{2} \times 4\mu$.
In pools.

Genus 32. **Sorastrum. Kutz.** (1845.)

Coenobium globose, solid within, free swimming, formed of 4–8–16–32 compressed wedge-shaped cells, which are sinuate, emarginate, or bifid at the apex, and radiately disposed. Propagation unknown (Fig. 30).

77. **Sorastrum spinulosum.** (Nüg.) Cooke, Algæ, t. 19, f. 1.

Coenobium spinulose. Cells wedge-shaped; apex slightly emarginate; angles obtusely rounded, bi-spinulose. Coenobium to $40\mu$ diam.
In stagnant water.

Genus 33. **Selenastrum. Reinsch.**

Cells semilunate, joined together by the middle of the convex margin, in families of 4–8, regularly disposed. Propagation unknown (Fig. 32).

78. **Selenastrum Bibraianum.** (Reinsch.) Cooke, Algæ, t. 19, f. 3.

Cells semilunate, with the cusps either expanded or curved inwards; minor families constituted of 4 cells in pairs, major families of these combined in more or less spherical masses. Cells $16–23 \times 5–8\mu$; minor families 23–31$\mu$ diam.
In moor pools.
Sub-Family 9. Characeæ.

Cells always innate, often distinctly stipitate, variable in form. Cell-membrane delicate, growing thicker with age; cell-contents bright green. Propagation by repeated division of the contents, resulting in more or less numerous biciliate zoogonidia.

Genus 34. CHARACIUM. Braun. (1847.)

Cells oblong, ovate, pyriform, fusiform, rarely acicular or subglobose, attenuated at the base in a hyaline stem. Cell-contents green. Zoogonidia succeeding division of the contents, occupying the whole of the cell, at length escaping by a lateral (rarely terminal) rupture, oblong, with two vibratile cilia (Fig. 34).

79. Characium Sieboldi. (Br.) Cooke, Algæ, t. 20, f. 9.

Cells erect, equal, at first nearly lanceolate, then pyriform or obovate, 2–3–4 times longer than broad, apex obtuse or broadly rounded; stem short, hyaline, base attenuated, truncate. Contents green at first, with one starch granule, afterwards several. Cells 22–26μ diam.

In clear water, attached to filiform algæ.

80. Characium ornithocephalum. (Br.) Cooke, Algæ, t. 19, f. 5.

Cells unequal, incurved, distinctly stipitate, afterwards one side swollen, semilunate, apex produced into a straight or inclined beak; stem elongated, slender, base sometimes discoid. Cell-contents bright green, with a central or lateral starch granule. Cells 25–33μ long, without stem, half as wide, or more.

In pools.

81. Characium tenue. (Herm.) Cooke, Algæ, t. 19, f. 4.

Cells erect, narrowly lanceolate, 6 times as long as broad, attenuated towards each extremity, somewhat ros-
trate, and hyaline above; stem short, slender, not dilated at the base. Contents homogeneous, bright green. Cells 3-6μ diam.
Attached to filamentous algæ.

**Genus 35. HYDRIANUM. Rabh. (1864.)**

Cells as in Characium, but cell-contents at first homogeneous, afterwards contracted into a dark green ovoid corpuscle, from which, by oblique division, 2-4-8 biciliate zoogonidia are produced (Fig. 33).


Cells at first globose-elliptical, attenuated below into a thin hyaline stem. Contents granular, then contracted in preparation for formation of the gonidia; zoogonidia elongated, escaping at the broadly opened apex. Cells, unopened, 8-9μ broad.
Attached to filamentous algæ.

**Genus 36. CODIOLUM. Braun. (1852.)**

Cells at first obovate, becoming clavate, or nearly cylindrical, densely aggregated in tufts; base attenuated into a stem. Cell-contents green. Propagation by zoogonidia, and by resting-spores.


Cells elongated, subclavate, green, many times longer than the diameter; apex rounded. Cells 30μ diam.
On maritime rocks. Also in the drip of fresh water.

**Family III. VOLVOCINÆ.**

Cœnobia mobile, globose, subglobose, or quadrangular and flattened, produced from agile biciliate green cells,
with a double contractile vesicle. Common tegument of the coenobium hyaline, more or less ample.

Propagation sexual or asexual.

Genus 37. Chlamydococcus. Br. (1849.)

Cells globose or subglobose (4–8 joined in a very fugitive coenobium). Cell-membrane thickish, firm; cell-contents granular, brownish red or vermilion, in certain stages changing into green. Macrogonidia 2–4–8 rounded, with very long cilia, involved in a very ample, hyaline tegument. Microgonidia much smaller, numerous, biciliate, moving actively within the mother-cell, and escaping (Fig. 37) by rupture.

84. Chlamydococcus pluvialis. (Br.) Cooke, Algae, t. xxi. f. 1.

Cells subglobose, very variable in size, brownish red, changing in some conditions to green. Cells 7–35μ.

On rocks, stones, etc., in hollows filled with rain-water.

85. Chlamydococcus nivalis. (Br.) Cooke, Algae, t. 21, f. 2.

Cells globose, red, at first with a hyaline border, which is the thickened epispore; this gradually disappears with age. Cells 10–30μ.

On snow and wet rocks, etc.

Genus 38. Chlamydomonas. Ehrb. (1833.)

Macrogonidia ovate or oblong, green, involved in a rather narrow hyaline tegument; frontal extremity very obtuse, or somewhat truncate, with a contractile vacuole, and two cilia; posterior extremity with a large vesicle. Microgonidia arising from repeated division of the contents of the macrogonidia, oblong or ovate, numerous, pale green or yellow, becoming brownish. Tranquil oospores globose, red or brownish (Fig. 38).
86. *Chlamydomonas pulvisculus*. (Ehr.) Cooke, *Algæ*, t. 21, f. 3.

Macrogonidia ovate, twice as long as broad, or nearly; deep green, with a bright red lateral spot. Diam. $6\frac{1}{2}-13\mu$.

In stagnant water.

**Genus 39. VOLVOX.** Linn. (1758.)

Coenobium spherical, continually rotating and moving, looking like a hollow globe, composed of very numerous cells arranged on the periphery at regular distances, connected by the matrical gelatin; furnished with a red lateral spot, two contractile vacuoles, and two long exserted cilia, all circumscribed with a common hyaline vesicle. Propagation sexual or non-sexual (Fig. 36).


Larger coenobia, with very numerous cells (12,000), always with daughter-coenobia enclosed within the mother, evolved without sexuality; fructification diœcious; the male coenobia nourishing numerous red fascicles of spermatozoa; the female coenobia originating 20–40 sexual cells, which after fecundation are resolved into as many red globose oospores, surrounded by a hyaline stellate epispore. Coenobium as much as 1 mm. diam.

In clear pools, ponds, etc.


Coenobia and the number of cells smaller; the number of daughter-coenobia evolved without sexuality within the mother, 1–9; fructification sexual, monœcious; many male cells, changing into bundles of spermatozoa; 5–10 female cells in the same coenobium, after fecundation, evolved into as many oospores, surrounded by a smooth epispore.

In similar places to the preceding.

**Genus 40. EUDORINA.** Ehrb. (1831.)

Coenobium oval, involved in a common tegument. Cells green, globose (16–32), enclosed within a single membrane,
bearing vibratile cilia, often with a red spot, distributed around the hyaline sphere at equal distances apart. Asexual propagation in all the coenobia, the cells of which are divided into 16-32 parts, and soon evolved into new coenobia. Sexual propagation in all the coenobia (Fig. 39).


Coenobia oval. Cells usually 32, globose, either scattered or quaternate, eight at each pole, distributed in three parallel circles, at equal distances from each other, around the periphery of the coenobium. Coenobium 40–150μ long; cells 18–22μ diam.

In standing water.

Genus 41. PANDORINA. Ehrb. (1830.)

Coenobium globose, or subglobose, invested by a broad colourless hyaline tegument. Cells green, globose (16, 32, or 64), included within a single rather thick membrane, bearing two vibratory cilia, with or without a red spot, aggregated in a botryoid manner. Propagation the same as in Eudorina (Fig. 41).

90. Pandorina morum. (Ehr.) Cooke, Algæ, t. 27, f. 2.

Coenobium globose. Cells green, 16–32, arranged about the periphery. In the forms which produce the resting-spores, the cells are crowded together in the centre. Resting-spores, after becoming encysted, bright red. Coenobium 200μ.

In standing water.

Genus 42. GONIUM. Müller. (1873.)

Coenobium quadrangular, tabular, angles rounded, formed from a single flat stratum of cells, girt by a broad hyaline plano-convex tegument. Cells 16 (central 4,
peripherical 12), polygonal, bright green. Propagation by division (Fig. 40).

91. Gonium pectorale. (Mull.) Cooke, Algae, t. 27, f. 1.

Cœnobium flattened, quadrangular, composed of 16 green cells, furnished with vibratile cilia. Cœnobium from 50μ; cells 10 × 7μ.

In stagnant water.

Genus 43. Stephanosphära. Cohn. (1852.)

Cœnobium throughout its whole life rotating and moving, composed of eight green cells, bearing two vibratile cilia, disposed at equal distances around a circle, enclosed in a common colourless hyaline, globose vesicle. Propagation both by macrogonidia and by microgonidia (Fig. 42).

92. Stephanosphära pluvialis. (Cohn.) Cooke, Algae, t. 28.

Cells globose, elliptic or fusiform, often at each extremity spreading out in mucous rays. Cœnobium 26–52μ; cells 6–12μ diam.

In hollows of rocks, and in pools after rain.

ORDER II. ZYGOPHYCEÆ.

Unicellular or multicellular, with terminal vegetation, destitute of true ramification. Cells single, or segregate, or geminate, or united in a series. Chlorophyl-mass for the most part distributed in plates or bands, including one or more starch granules. Multiplication by division in one direction. Propagation by zygospores resulting from the conjugation of two cells.
Family I. Desmidieae.

Unicellular. Excluded from this volume as a special study.

Family II. Zyg nemaceae.

Multicellular. Cells cylindrical; fructiferous cells more or less inflated, all closely joined in filamentous families, forming an articulated simple thread, with a central cytoblast involved in radiating protoplasm. Cell-walls lamelllose. Chlorophyl-mass effused, or of a definite form, often forming a spiral band. Propagation by zygospores, resulting from conjugation.

Sub-Family 1. Zyg nemae.

Zygospore undivided, and mostly contracted, passing into the resting condition, afterwards developing into a germ-cell, divided into a basal cell and a thread-cell, capable of division.

Genus 44. Zygema. Kutz. (1843.)

Cells with two axile many-rayed chlorophyl bodies near the central cell nucleus, with a starch granule, or filled with dense granular contents, surrounding two starch granules lying near the centre. Zygospore in the middle space between the united pairing cells, or in one or other of the conjugating cells (Figs. 43, 44).

A. Zygospores produced in conjugating canal.

93. Zygema pectinatum. (Ag.) Cooke, Algæ, t. 29, f. 1.

Sterile cells 1 to 2 times as long as broad. Zygospores globose or broadly elliptic, dark olive, scrobiculate, formed
in the canal of conjugation. Cells 30–35μ diam.; zygosporangium 40μ diam.
In still waters.

94. Zygnema Ralfsii. (Kutz.) Cooke, Algæ, t. 29, f. 2.
Sterile cells 2½ to 3 (rarely 4) times as long as broad. Zygospore compressed ellipsoid, twice as long as broad, produced in the inflated conjunctive canal; sporoderm even. Cells 16–17μ diam.; zygospores 25 × 15μ.
In pools and streams.

95. Zygnema parvulum. (Kutz.) Cooke, Algæ, t. 29, f. 2.
Sterile cells 4 to 6 times as long as broad. Zygospore globose, produced in the conjunctive canal. Cells 20–22μ diam.; zygospores about equal.
In standing pools.

B. Zygospores produced in one or other of the conjugating cells.

Sterile cells equal, or twice as long as broad. Zygospore spherical, formed in one or other of two conjoined cells; membrane brown and scrobiculate. Cells 28μ broad; zygospores 40μ diam.
In ditches, pools, etc.

97. Zygnema stellinum. (Vauch.) Cooke, Algæ, t. 30, f. 2.
Sterile cells 1½ to 3 times longer than broad. Zygospore broadly ovoid, formed in one or other of the conjoined cells; membrane brown, scrobiculate. Sporiferous cells commonly longer than the zygospore. Cells 22μ diam.; zygospore 40 × 30μ.
In pools and ditches.

98. Zygnema Vaucherii. (Ag.) Cooke, Algæ, t. 30, f. 3.
Sterile cells 2½ or 3 to 5 times as long as broad. Zygospores subglobose or broadly elliptic, produced in one or
other of the conjugating cells, which is usually more or less inflated; sporoderm delicately punctate. Cells 10–22μ diam.; zygospore, according to the varieties.

In ditches, ponds, etc.

Sterile cells 19–22μ, 1 to 3 times as long.

var. b. subtile. (Rabh.) Cooke, Algæ, t. 30, f. 4.
Sterile cells 15–19μ, 2 to 4 times as long.

var. c. stagnale. (Kirsch.) Cooke, Algæ, t. 30, f. 5.
Sterile cells 10μ, 3 to 4 times as long.

Sterile cells equal, or nearly twice as long as broad; cytioderm thick, lamellose. Zygospore globose, olivaceous (sporoderm distinctly punctate?). Cells 25μ diam., with mucous sheath about double; zygospore 26μ diam.

In boggy pools.

100. Zygnema leiospermum. (De Bary.) Cooke, Algæ, t. 31, f. 2.
Sterile cells equal in length and breadth, or sometimes twice as long. Zygospore globose or broadly oval, formed in one of two conjugating cells; membrane brown, even. Sporiferous cells a little swollen. Cells 22μ diam.; zygospore 23–30μ.

In ditches filled after rain.

101. Zygnema insigné. (Kutz.) Cooke, Algæ, t. 31, f. 3.
Sterile cells equal, or twice as long as broad. Copulation scalariform or lateral; zygospore globose or slightly oval; membrane brown, even. Cells 26–30μ diam.; zygospore 26 × 30μ, or globose 30μ.

In streams and ditches.

Genus 45. SPIROGYRA. Link. (1820.)
Cells with one to several chlorophyl bands, usually spirally winding to the right. Copulation ladder-like or
lateral. Zygospores always within the wall of one of the united cells. Copulating cells similar to the sterile ones, or swollen (Fig. 45).

SECTION 1. Cells not replicate at the ends.

A. Chlorophyl bands numerous (rarely two).

102. Spirogyra crassa. (Kutz.) Cooke, Algæ, t. 32, f. 1.

Sterile cells with the extremities truncate, equal or twice as long as broad; chlorophyl bands 3 or more, making \( \frac{1}{2} \) to \( 1 \frac{1}{2} \) turns. Zygospores broadly and obtusely oval; membrane even. Sporiferous cells persistent, not swollen. Cells 150\( \mu \) diam.; zygospore 160 \( \times \) 120\( \mu \).

In ponds, etc. Fruiting in summer.

103. Spirogyra jugalis. (Dillw.) Cooke, Algæ, t. 32, f. 2.

Sterile cells with the ends truncate, and commonly equal or double the length of the diameter; chlorophyl bands 4 to 5, making 1 to 2 turns. Zygospore elliptical; membrane even. Sporiferous cells not swollen. Sterile cells 90–100\( \mu \) diam.; zygospores 130–140 \( \times \) 85–90\( \mu \).

In clear ponds, etc. Fruiting at Midsummer.

104. Spirogyra nitida. (Dillw.) Cooke, Algæ, t. 33, f. 1.

Sterile cells with the ends truncate, and usually 2 to 4 times as long as broad; chlorophyl bands about 4, making 1 to 4 turns of the spiral. Spores elliptic ovoid (almost almond shaped), 1\( \frac{1}{2} \) times as long as broad; membrane even. Sporiferous cells persistent. Sterile cells 70–90\( \mu \); zygospore 110–160 \( \times \) 60–70\( \mu \).

In ponds.

105. Spirogyra orthospira. (Näg.) Cooke, Algæ, t. 33, f. 2.

Sterile cells with the extremities truncate, and from 2\( \frac{1}{2} \) to 4 to 10 times as long as broad; chlorophyl bands 3 to 4 to 5 (rarely 7), sometimes erect, sometimes forming a very lax spiral. Spores orbicular, flattened; membrane even.
Sporiferous cells scarcely swollen, $2\frac{1}{2}$ to 4 times as long as the diameter. Cells 50–65 μ diam.; zygospore 70 × 48 μ.

In pools. Fruiting in autumn.


Sterile cells with the end truncate, about equal in length to breadth; chlorophyl bands 5 to 7, making $\frac{1}{2}$ to 1 turn. Zygospores orbicular, flattened; membrane punctate. Sporiferous cells not inflated. Cells 110–140 μ diam.; zygospores 100 μ diam.

In ponds, etc. Fruiting in autumn.


Sterile cells with the end truncate, and usually 1$\frac{1}{2}$ times (rarely 3 times) as long as broad; chlorophyl bands 5 to 6, making $\frac{1}{2}$ to 1 turn, or nearly erect. Spores orbicular, depressed, with the membrane punctate or porose, chestnut colour. Sporiferous cells persistent, swollen. Cells 70–80 μ; zygospores 70–80 μ diam.

In ponds. Fruiting in August.

B. Chlorophyl bands single or double (rarely ternate).

108. Spirogyra porticalis. (Vauch.) Cooke, Alga., t. 35.

Sterile cells with the extremities truncate, 2 to 4 times longer than the diameter; chlorophyl bands single or binate, rarely ternate. Spores obtuse, ovoid, 1$\frac{1}{2}$ times longer than the diameter; membrane even, chestnut colour. Sporiferous cells equal to the length of the spore, or twice as long, more or less turgid. Cells 32–50 μ diam.; spores 80 × 48–50 μ.

In ditches, etc. Fruiting in spring.


Chlorophyl bands usually single.

var. b. decimina. Cooke, Alga., t. 35, f. 2.

Chlorophyl bands usually 2, sometimes 3. Cells 34–40 μ, 2 to 4 times as long.
var. γ. rivularis. (Hass.) Cooke, Alga, t. 35, f. 3.
Cells 32–36μ, 5 to 10 times as long.

C. Chlorophyl bands single.

Sterile cells with the extremities truncate, and commonly 1 to 3½ times longer than the diameter; chlorophyl bands single, rarely 2, making 1½ to 2 turns of the spiral. Spores broadly obtuse, ovoid, or subspherical; membrane even, chestnut colour. Sporiferous cells turgid, and usually shorter than the spores. Cells 40μ diam.; zygospores 35–40μ diam.
In pools. Fruiting in spring.

110. Spirogyra velata. (Nordst.) Cooke, Alga, t. 130, f. 1.
Sterile cells with the ends truncate, 3 to 4 times as long as broad; chlorophyl band single, making 1½ to 2½ turns. Spores elongated-oval, 1½ to 3 times as long as broad. Epispore thick, of 4 membranes; the second hyaline and scrobiculate; the third coloured. Sporiferous cells a little swollen or not at all, shorter, or a little longer than the spores. Cells 35–40μ; zygospores 60–85 X 35–45μ.
In ditches.

111. Spirogyra longata. (Vauch.) Cooke, Alga, t. 36, f. 2.
Sterile cells with the ends truncate, 3 to 8 times as long as broad; chlorophyl bands single or rarely 2, making 1½ to 6 turns of a spiral. Spore 1½ to 2 times as long as broad; membrane even, chestnut colour. Sporiferous cells swollen and usually longer than the spore. Cells 24–30μ diam.; zygospores 40–70 X 30μ.
In pools and ditches.

var. a. communis. Cooke, Alga, t. 36, f. 2 e.
Sterile cells 3 to 8 times as long as broad.

var. β. turpis. Cooke, Alga, t. 36, f. 2 f.
Sterile cells abbreviated.
112. Spirogyra flavescens. (Hass.) Cleve.

Sterile cells with the ends truncate, 2½ to 5 times longer than broad; chlorophyll bands single. Spores attenuated, twice as long as broad; membrane even, chestnut colour. Sporiferous cells swollen, and usually longer than the spores. Cells 20μ diam.; zygospore 50 × 24μ.

Boggy pools on heaths, etc.

Zygospore about 30μ diam.

form b. flavescens. Cooke, Alge, t. 37, f. 2.
Zygospore about 20μ diam.

form c. parva. Cooke. Alge, t. 37, f. 3.
Zygospore about 10μ diam.

Section 2. Cells replicate at the ends.

A. Chlorophyll bands usually two or more.


Sterile cells with the extremities replicate, 4½ to 5 (rarely 6) times as long as broad; chlorophyll band 2 to 3, lax, with 1 to 2 turns of spiral, or nearly erect. Spores ovate-elliptic, twice as long as broad; membrane even. Sporiferous cells slightly swollen. Cells 30–35μ; zygospore 40–50μ, 2 to 3 times as long.

In streams.

114. Spirogyra calospora. (Cleve.) Cooke, Alge, t. 38, f. 2.

Sterile cells with the extremities replicate, 6 to 12 times as long as broad; chlorophyll bands 1 to 3, making 2½ to 7 turns. Spores elongate, obtuse ovoid, 1½ to 2 times as long as broad; membrane yellow, scrobiculate. Sporiferous cells scarcely turgid.

form a major.

Diameter of threads 50μ. Bands 2 to 3.
INTRODUCTION TO FRESH-WATER ALGÆ.

form β minor.

Diameter of threads 32μ. Band single. Zygospore 78–96 × 45μ
In bogs and moor pools.

B. Chlorophyl bands single.


Sterile cells 3 to 9 times as long as broad. Fertile cells turgid, quadrate. Zygospore elliptical. Sporoderm brown. Cells 24 to 27μ; zygospore 42–48μ diam., 1½ to 2 times as long.
In pools.

116. Spirogyra Weberi. (Kutz.) Cooke, Algae, t. 39, f. 2.

Sterile cells with the extremities replicate, 7 to 12 times as long as the diameter; chlorophyl bands single, 3 to 8 turns of the spiral. Spores ovoid, scarce broader than the sterile threads; membrane even, chestnut, twice as long as broad. Sporiferous cells scarcely turgid. Spores: (a) 72 × 34μ; (β) 68 × 34μ.

form a. inæqualis.

Diameter of thread 30μ. Sporiferous cells scarcely longer than the spores.

form β. subventricosum.

Diam. of thread 26μ. Sporiferous cells 2 to 4 longer than the spores.
In ditches. Fruiting in summer.

117. Spirogyra tenuissima. (Hass.) Cooke, Algae, t. 39, f. 3.

Sterile cells with the extremities replicate, 5 to 15 times as long as the diameter; chlorophyl bands single, making 3 to 6 turns of the spiral. Spores broader than the sterile cells, elongated ovoid, twice as long as the diameter; membrane even and chestnut colour. Sporiferous cells turgid. Spore 55–58 × 24–30μ.
form a. tenuissima.

Sterile cells 12–15μ diam., 8 to 16 times as long as broad. Sporiferous cells 2 to 3 times as long as the spores.

form b. inflata.

Sterile cells 17–20μ diam., 5 to 10 times as long as broad. Sporiferous cells scarcely longer than the spores. In pools.

Genus 46. SIROGONIUM. Kutz. (1843.)

Cells with parietal longitudinal chlorophyl bands. Fructifying cells bending knee-like towards each other and growing together, united at the point of adnation; receiving-cells barrel-shaped; giving-cells short, cylindrical. Zygospore (elliptic) in the receiving cell-wall (Fig. 46).

118. Sirogonium stieticum. (Kutz.) Cooke, Alg., t. 40, f. 1.

Sterile cells 2 to 5 times as long as broad. Zygospore broadly elliptical, spore-coat double. Sporiferous cells swollen, abbreviated. Cells 40 to 50μ, 2 to 5 times as long; zygospore 42 × 75μ.

In ponds and ditches and moor pools.

Genus 47. ZYGOGONIUM. Kutz. (1843.)

Cells cylindrical or barrel-shaped, with a compact cell-wall. On each side an irregular chlorophyl-body, each furnished with a starch granule, both often confluent in an axile string. Connection of the copulating threads ladder-like. The protuberances of the two contiguous threads that receive the chlorophyl-contents are bounded by partitions into fructifying cells, which then coalesce into a not-contracted zygospore (Fig. 47).
INTRODUCTION TO FRESH-WATER ALGÆ.


Sterile cells $1\frac{1}{2}$ to 2 times as long as broad. Zygospores subglobose or oblong. Sporoderm rather thick, even. Cells 13–18μ diam.; zygospore 13 × 25 mm.

var. a. terrestris.

Growing on the ground on heaths.

var. b. aquaticum. Cooke, Algx, t. 40, f. 3.

In pools, bogs, etc.

Doubtful Species.

120. Zygogonium gracile. (Berk.) Cooke, Algx, t. 40, f. 4.

Sterile cells about 5 times as long as broad, of a pale or yellowish green colour. Zygospore unknown. Cells 14–16μ diam.

d. of a dripping rock.

Genus 48. MOUGEOTIA. De Bary. (1858.)

Cells with axile chlorophyl-plates. Copulation ladder-like. Zygospore drawn together in the swollen, bladdery, persisting middle space (Fig. 48).

121. Mougeotia glyptosperma. (De Bary.) Cooke, Algx, t. 41, f. 2.

Sterile cells 7 to 12 times as long as broad. Zygospores large, oval, with a thick, firm, yellow-brown epispore. Sporiferous cells elongated. Cells 10–15μ, 6 to 10 times as long; zygospore 16 × 35μ.

122. Mougeotia lævis. (Archer.) Cooke, Algx, t. 41, f. 2.

Sterile cells twice as long as broad. Zygospores broadly elliptic or oval. Epispore thick, brown. Sporiferous cells sometimes elongated. Cells 20–25μ; zygospore about 45 × 36μ.

In ditches and pools.
Sub-Family 2. Mesocarpeae.

Cells cylindrical, united in threads, with axile plates of chlorophyl. Zygospore the shape of the mother-cells; not contracted, separating by three to five partitions into a central firm-walled resting-spore, and two or four lateral decaying cells.

Genus 49. Mesocarpus. Hass. (1815.)

Spore spherical or oval, between two cylindrical, straight or slightly inbent lateral cells. (a) Copulation ladder-like, threads free, or with one end attached; (b) copulation lateral between two neighbouring cells of a thread, rarely ladder-like. Sterile cells often with a knee-like bend, and intergrown at the bend with similar cells of another thread (Figs. 49, 50).

† Spore membrane scrobiculate or punctate.

123. Mesocarpus nummuloides. (Hass.) Cooke, Algæ, t. 41, f. 3.

Sterile cells 7 to 14 times as long as broad. Zygospore spherical, or broadly ovoid; membrane brown, scrobiculate. Cells 15μ diam.; zygospore 44 × 34μ.

In ditches. Fruiting in September.

124. Mesocarpus depressus. (Hass.) Cooke, Algæ, t. 41, f. 4.

Sterile cells 7 to 12 times as long as broad. Zygospore elliptical, compressed; membrane brown, punctate. Cells 7–15μ diam.

var. B. ovalis. (Rabh.) Cooke, Algæ, t. 41, f. 5.

In boggy waters.
INTRODUCTION TO FRESH-WATER ALGÆ.

†† Spore membrane smooth.

125. Mesocarpus parvulus. (Hass.) Cooke, Algæ, t. 42, f. 3.
Sterile cells 5 to 12 times as long as broad. Zygospore spherical; membrane even, commonly twice the diameter of the threads. Cells 10μ; zygospore 20–24μ.

var. B. angustus. (Hass.) Cooke, Algæ, t. 42, f. 4.

Sterile cells 2 to 4 times as long as broad. Zygospore spherical or broadly ovoid; membrane brown, even, about equal in diameter to the threads. Cells 34μ diam.; zygospore 34μ diam.

In boggy pools, etc.

Sterile cells 5 to 10 times as long as broad. Zygospore globose. Sporoderm brown, even. Cells 12–18μ.

In ditches.

Sterile cells with the endochrome in a single axile plate. Conjugation lateral. Zygospores oval, 90μ × 40μ; sterile cells 25μ long; 20–25μ broad.

In a duck-pond.

Sub-Genus Pleurocarpus. Braun.

129. Mesocarpus pleurocarpus. (De Bary.) Cooke, Algæ, t. 43, f. 1.
Sterile cells 2 to 3 times as long as broad. Zygospores subglobose, brown, even. Cells 25–30μ.

In moor pools, etc.

Genus 50. Stauropspermum. Kutz. (1843.)
Spores 4-cornered, between the truncated corners of 4 sessile lateral cells (cells of all the species up to 20 times longer than broad) (Figs. 51, 52).

† Sporoderm porose.
130. Staurospermum quadratum. (Hass.) Cooke, Algae, t. 43, f. 2.

Sterile cells 10 to 20 times longer than broad. Epispore quadrangular, with the angles truncate, not replicate; sides straight, covered with large pores (about 50 on the longer side). Cells 15–20μ; zygospore 40–44μ.

In ponds, ditches, etc.

† Sporoderm verrucose.

131. Staurospermum gracillimum. (Hass.) Cooke, Algae, t. 43, f. 3.

Sterile cells 8 to 15 times as long as broad, pale yellowish green. Zygospore quadrate; the sides deeply sinuate; angles retuse. Sporoderm verrucose. Cells 6–8μ; zygospore 20μ diam.

In bogs and moor pools.


Sterile cells 6 to 14 times as long as broad. Zygospore quadrate; angles obtuse or truncate; sides often deeply sinuate. Sporoderm even, 15 × 20μ; zygospore 50 × 40μ.

In ditches and ponds.

133. Staurospermum viride. (Kutz.) Cooke, Algae, t. 44, f. 2.

Sterile cells 10 to 20 times as long as broad. Epispore quadrangular; angles truncate and replicate; sides concave, smooth. Cells 8μ; zygospore 25μ.

In ditches.

Sub-Family 3. Gonatanemæ.

Cells cylindrical, much elongated, united in threads, with axile plates of chlorophyl. Agamospores produced without conjugation in cells continuous with, and partitioned from the mother-cells.

Genus 51. Gonatanema. Wittrock. (1878.)

Spores (agamospores, not carpospores) without conjugation, formed by biseptation of the mother-cells, which
latter are bent angularly, and alternately, at the point of fructification (Fig. 53).

134. *Gonatonema notabile.* (Hass.) Cooke, Algæ, t. 44, f. 3.

Sterile cells 8 to 10 times as long as broad, sometimes longer. Zygospore, front view cylindrical, side view bent so as to be convex on one side, concave on the other, truncate at the ends, same diameter as the vegetative cells. Cells 12–15 μ.

In fields.

**ORDER III. SIPHOPHYCEÆ.**

Unicellular, or, when fruiting, bicellular. Cells utricle-shaped, often branched; branches with terminal vegetation, at length shut off by a septum, some containing oospores, others antheridia. Propagation by free cells, zoogonidia, or oospores. Aquatic or terrestrial.

**FAMILY I. BOTRYDIACEÆ.**


**Genus 52. BOTRYDIUM.** (Wallr.)

Same as above (Fig. 54).

135. *Botrydium granulatum.* (Linn.) Cooke, Algæ, t. 65.

Gregarious, often aggregated, rarely confluent. Cells globose, pyriform, size of a poppy seed or mustard seed, or larger, leek-green, pulverulent.

On the ground in swampy places.
FAMILY II. VAUCHERIACEÆ.

Monoecious, rarely dioecious, cespitose, unicellular, or bicellular. Thallus more or less branched, vegetation terminal. Propagation sexual or non-sexual. Oogonium lateral, sessile, or stipitate. Antheridia lateral, sessile. Spermatozoids oblong.

Genus 53. VAUCHERIA. (D. Cand.)

Characters same as above (Fig. 55).

Section A. Tubuligeræ. Antheridia little or scarcely bent.


Loosely cespitose, dirty green. Thallus very thick, remotely dichotomous. Oogonia sessile, globose, or ovoid, single. Oospores with a triple membrane, spotted with brown. Antheridia single, erect, on the same or on different threads. Oogonia $\frac{1}{10}$ mm. diam.; threads $\frac{1}{3}$ mm. diam.

In ditches, and in brackish water.


Loosely cespitose, sparingly branched. Fructification similar to V. sericea, but thallus much thicker. Oogonia larger, now and then somewhat pedicellate. Oospores much smaller.

In ditches.


Tufts densely interwoven, dirty green; thallus thin, loosely branched. Oogonia 2 to 6 in a series, oblique, rostellate, sessile or shortly pedicellate. Antheridia cylindrical, horizontally deflexed. Spermatozoids oblong. Oogonia $\frac{1}{10}$ mm.

In ditches; etc.
Section B. Corniculatae. Antheridia bent, or hooked, on short lateral branches.

139. Vaucheria Dillwynii. (Ag.) Cooke, Algæ, t. 47, f. 9, 10.

On the ground in damp shady places.

140. Vaucheria sessilis. (Vauch.) Cooke, Algæ, t. 46.

Loosely intricate, pale or dull green. Thallus sparingly branched. Oogonia 2 to 3, approximate, rarely single, ovate, oblique, rostrate. Antheridia intermediate, short, straight, and subulate, or elongated and incurved. Oospores punctate. Oospores and threads 70μ diam.
In ditches or on the ground.

var. caespitosa. (Vauch.) Cooke, Algæ, t. 48, f. 3.

Oogonia usually in pairs, ovate, opposite. Antheridia intermediate, generally short, circinate.
On the margin of streams.

var. ornithocephala. (Hass.)

Oogonia solitary, or in pairs, oval-oblong, obliquely rostrate, beaks truncate. Antheridia cylindrical-subulate.
In stagnant or slow-flowing water.

var. repens. (Hass.) Cooke, Algæ, t. 48, f. 4.

Terrestrial. Oogonia single, sessile, oblong or ovate, mouth lateral, truncate. Antheridia solitary, erect or curved, scarcely longer than the oogonium.
On the naked ground.

141. Vaucheria geminata. (Vauch.) Cooke, Algæ, t. 48, f. 6-9.

Dense dull green tufts. Thallus dichotomous. Oogonia 2 (rarely 1 to 3), ovate, opposite, pedunculate. Antheridia
VAUCHERIACEÆ.  237

intermediate, subulate, recurved. Oospore spotted. Sporo-
derm colourless, stratose, 110–120 × 180–190μ.
In ponds and ditches.

*var. racemosa.* (Grev.) Cooke, *Alga*, t. 49, f. 4.

Oogonia shortly pedunculate, 3 to 5, or more, aggre-
gated in a corymbose manner. Antheridia single, scarcely
longer than the oogonia. Oospore 60–80 × 75–80μ.
In ditches.


Aquatic or terrestrial. Thallus vaguely branched. Oogonia usually single, ovate, seated on a short segment
of the divided stem, the other segment forming the
antheridium.
In ditches.


Densely interwoven in a bright green stratum. Oogonia
usually single, pedunculate, attached at the back of the
curved antheridia. Oospores with a colourless inflated
sporoderm.

On damp clay soil.

**Section C. Piloboloideæ.** Antheridia bordering imme-
diately on the boundary cell.


Loosely cæspitose. Antheridia at tips of the branches,
tumid, a little incurved, acuminate, furnished at the apex
with 2 (rarely 4) conical processes, connected with the
side or base of the oogonium by means of a short cell
without chlorophyll. Oogonium globose. Threads 26–60μ; 
oogonia 104–136μ; oospore 88–120μ.

On mud of Thames at low water.
238 INTRODUCTION TO FRESH-WATER ALGÆ.

ORDER IV. NEMATOPHYCEÆ.

Multicellular, membranaceous or filamentous, with or without branches. Vegetation either terminal, forming an articulate thread, or afterwards lateral, forming a membranaceous thallus of a single stratum. Cell-multiplication by repeated division in one or two directions. Propagation by oospores or zoogonidia.

FAMILY I. ULVACEÆ.

Thallus membranaceous or foliaceous, rarely crustaceous, formed of one stratum of cells. Propagation by zoogonidia, arising from a repeated division of the contents. Zoogonidia oblong, with two or four cilia.

Sub-Family 1. Prasioleæ.

Thallus expanded and foliaceous, rarely crustaceous.

GENUS 54. PRASIOLA. Ag.

Thallus membranaceous, foliaceous, ascending or erect, more or less crispate, composed of angular cells, distributed in plane areas; base sometimes loosely fibrillose (Fig. 56).

145. Prasiola crispa. (Kutz.) Cooke, Algæ, t. 50, f. 1, 2.

Tufts more or less dense, dark green, soft and elastic. Thallus plicate crisped, of variable form and size, often bullate. Cells in distinct areolas, or confluent, quadrate, or quadrangular; angles more or less obtusely rounded. Cells 5–9 μ diam., or 8–13 × 3–5 μ.

On damp ground, rocks, etc.
146. Prasiola furfuracea. (Menegh.) Cooke, Algæ, t. 50, f. 5-7.

Forming a furfuraceous stratum, more or less expanded, dark green. Thallus about a line long and broad, dilated from the short stem-like base into a fan-like lamina; margin slightly undulate and repand, often emarginate at the apex or lobed. Cells angular, in quadrate or almost quadrate areolas. Cells 14–16 × 4–6 µ.

On damp walls and rocks.

147. Prasiola stipitata. (Suhr.) Cooke, Algæ, t. 50, f. 8-11.

Stratum caespitose, expanded, dark green. Thallus variable, commonly 1 to 2 lines long; dilated upwards from a stem-like base, often truncate at the apex; margin slightly repand. Cells in the stem-like base in series, in the upper part in small regular areolas. Cells 5–7 µ.

On rocks by the sea, etc.

148. Prasiola calophylla. (Spreng.) Cooke, Algæ, t. 50, f. 3, 4.

Caespitose, dark green, crispate. Thallus 2 to 4 lines long, narrow, linear, rather circinate, attenuated at the base into a stem, truncate at the apex, now and then crenate. Cells large, arranged in longitudinal series. Cells 4–5 × 2–4 µ.

On damp stones, rocks, etc.

Sub-Family 2. Ulvææ.

Thallus membranaceous, vesiculose, or tubulose.

Genus 55. ENTEROMORPHA. Link. (1820.)

Thallus membranaceous, tubular or bladdery, fixed at the base; composed of one stratum of cells, sometimes branched. Propagation by zoogonidia (Fig. 57).
240 INTRODUCTION TO FRESH-WATER ALGÆ.


Fronds simple, elongated, variable in form and size, usually becoming more or less inflated, obtuse above, attenuated at the base, pale green. Cells 3-5-6 angled. Cells 12-20μ diam.
In ditches, chiefly brackish.

Genus 56. MONOSTROMA. Thur. (1854.)

Frond plane or saccate, simple, or torn, or lobate, composed of one stratum of cells. Cells somewhat rounded, immersed in a homogeneous membrane (Fig. 58).

150. Monostroma laceratum. (Thur.) Cooke, Algæ, t. 51, f. 6,7.

Thallus membranaceous, thin and flaccid, pallid green, rugose; margin plane, or crisped (40-50μ thick). Cells rounded, twin, ternate, or quaternate, disposed loosely in the intercellular substance, in transverse section of the thallus oval (17-23μ).
In brackish water.

151. Monostroma Wittrockii. (Born.) Cooke, Algæ, t. 51, f. 8-12.

Thallus membranaceous, gelatinous, bright green (18 mill.), oblong, pedicellate, at first saccate, then open at the summit, margin becoming regularly lobed. Adult plant sessile, attached by a part of its surface, when mature (8 cent. diam.), the lobes plicate, elongated and rounded. Cells angular, subquaternate, in section of thallus rounded.
In salt or brackish water.

Family II. Sphaeropleaceæ.

Threads simple, with terminal vegetation, very long, articulations cylindrical, by spurious septa multilocular. Chlorophylloose mass distributed in annular bands. Pro-
pagation by oospores, after sexual fecundation, enclosed in a stellate sporoderm.

**Genus 57. SPHÆROPLEA.** Ag. (1824.)

Characters the same as above (Fig. 59).

152. Sphæroplea annulina. *(Roth.)* Cooke, *Algæ,* t. 52.

Green, yellowish, brick-red, or scarlet. Cells 8 to 10 or 20 times as long as broad, with 20 to 30 chlorophylllose rings in each cell. Spores at length densely seriate, rarely disposed irregularly, at first green, afterwards olive-brown, and then red. Threads 36–70μ diam.; oospore 18–30μ.

In quarries, pits, or inundated fields.

**Genus 58. CYLINDROCAPSA.** Reinsch. (1867.)

Cells spherical or ellipsoid; membrane thick, either with a three or fourfold tegument, or naked; cells associated in a linear series, enclosed in a cylindrical hyaline gelatinous tube; cells dividing transversely, Cell-contents green, granular (Fig. 60).

153. Cylindrocapsa involuta. *(Reinsch.)* Cooke, *Algæ,* t. 9, f. 3.

Cells ellipsoid, ultimately involved in a fourfold tegument, which is expanded at the poles. Cells 22–30μ diam.

In pools, etc.

**Family III. CONFERVACEÆ.**

Threads articulate, either simple or branched, vegetation terminal. Articulations more or less elongated, rarely abbreviated, cylindrical, rarely swollen. Cell-membrane sometimes lamellose. Vegetation by repeated division in one direction. Propagation by zoogonidia.
SECTION 59. MICROSPORA. Thur. (1851.)

Articulate thread simple. Chlorophyllose mass at first parietal, afterwards contracted in the centre. All articulations fertile. Propagation by zoogonidia, arising from a division of the cell-contents, escaping by rupture of the cell (Fig. 61).


Pale green or yellowish green. Articulations before division 4 to 5 times as long as their diameter, after division about 2 to 2½ times as long, not constricted at the joints. Cells 8½–10μ diam.
In ditches.


Bright green. Articulations 2 to 3½ times as long as the diameter. Threads 12μ diam.
In ditches and pools.

156. Microspora floccosa. (Ag.) Cooke, Algæ, t. 53, f. 3.

Articulations about twice as long as broad, after division equal, or a little shorter, slightly constricted at the joints. Threads 8–10 or 15μ diam.
In stagnant water.

SECTION 60. CONFERVA. (Linn.)

Articulate threads simple, joints cylindrical. Chlorophyllose mass homogeneous. Vegetation by division Fig. 62).

57. Conferva fontinalis. (Berk.) Cooke, Algæ, t. 53, f. 6, 7.

Bright green, attached. Articulations 6 to 10 times as long as the diameter, slightly swollen, a little constricted at the joints. Cell-membrane rather thick, homogeneous; when heated with sulphuric acid, swelling and distinctly lamelllose. Threads 16–18μ diam.
Attached to grass, etc., in ditches.

Usually pale green. Articulations $1\frac{1}{2}$–3 times as long as the diameter. Threads $3\frac{1}{2}$–$5\mu$ diam. In fresh water, often mixed with other algae.


Yellowish green or green, soft, silky. Articulations oblong-cylindrical, slightly constricted at the joints, before division three times as long as the diameter, collapsing alternately when dry. Threads 6–12$\mu$ diam. In ditches, pools, etc., common.

**Genus 61. Chaetomorpha. Kutz. (1845.)**

Articulate thread simple, nearly equal, fixed by a discoid base. Lower articulations always short; before division equal or half as long again as broad; after division shorter. Upper articulations elongated. Cell-membrane thick; cell-contents green. Propagation by zoogonidia (Fig. 63).


Rigid, green, crispate. Articulations, before division, $1\frac{1}{2}$ times as long as broad, here and there swollen in pairs, and discoloured. Threads $160\mu$ diam. In estuaries.


Rather rigid, dark green, or yellowish green. Lower articulations equal or almost equal in length to their diameter. Upper articulations, before division, two or three times as long as the diameter, or even four times, here and there swollen. Cell-membrane of the lower articulations thick, distinctly lamellolose; the upper ones thinner and indistinctly lamellolose, contracted at the joints. Threads '25 mm. thick. In brackish and salt water.
162. Chaetomorpha sutoria. (Berk.) Cooke, Algæ, t. 54, f. 5.

Dark green, crispate, rather rigid, interwoven in lax tufts. Articulations one and a half times as long as broad, after division shorter than the diameter. Cell-membrane thick, distinctly lamellose. Threads 100–120μ diam.

In brackish ditches, estuaries, and salt water.

163. Chaetomorpha implexa. (Dill.) Cooke, Algæ, t. 54, f. 6.


In brackish water.

Genus 62. RHIZOCLONIUM. Kutz.

Articulate thread as in Conferva, distinctly contorted, forming by proliferation of the cells short root-like processes (Fig. 64).

164. Rhizoclonium Casparyi. (Harv.) Cooke, Algæ, t. 54, f. 7.

Threads elongated, slender, decumbent, yellow green, stratified, interwoven, curved and angular, emitting short root-like branches at the angles. Joints 2 to 6 times longer than broad, with narrow dissepiments. Threads 18–25μ diam.

In brackish water.

165. Rhizoclonium flavicans. (Jurg.) Cooke, Algæ, t. 54, f. 8.

Threads soft, simple, extremely fine, matted, somewhat crisped, at first pale green, at length distinctly jointed. Articulations one and a half as long as broad, dotted; interstices pellucid. Threads 18μ diam.

At the mouths of rivers, and salt marshes.


Cells 20 × 12½μ.
Genus 63. **Cladophora.** Kutz. (1843.)

Articulate thread variously branched. Cell-membrane usually thick, lamellose; cell-contents parietal. Propagation by zoogonidia, furnished with 2 or 4 vibratile cilia (Fig. 65).

166. *Cladophora fracta.* (Dillw.) Cooke, Algae, t. 55, f. 1, 2.

Branches sparse, divaricate, the lower laterally inserted. Cell-contents of the branches not spiral. Fertile cells often in the middle of the branches or basal. Threads 100μ diam.

In fresh or brackish water.

167. *Cladophora crispata.* (Roth.) Cooke, Algae, t. 55, f. 3, 4.

Less coloured than the preceding, now and then dark green, sometimes colourless. Branches and branchlets remote, sometimes secund; insertion apical, articulations collapsing. Cell-contents disposed in a lax spiral. Cell-membrane delicately plicate-striate. Primary branches 22μ thick; ultimate branches less than half that diameter; main thread 120μ diam.

In pools.


Branches in the upper part of the primary thread and branchlets of the second and third order usually fasciculate or penicellate. Cell-contents of the larger cells applied in a net-like or spiral manner to the walls. Fructiferous cells always terminal, with the lower cells sterile. Primary and secondary branches to 60μ diam., 3 to 6 times as long.

In clear streams and rivulets, usually attached to stones.

169. *Cladophora flavescens.* (Ag.) Cooke, Algae, t. 55, f. 5-7.

Pale yellowish, 6 inches long, very much branched, fasciculate in a plumose manner. Branches patent; ultimate branchlets often rather clavate, patent or incurved.
Cell-membrane often distinctly plicate; cell-contents distributed in a reticulate manner. Diameter of branches 70–80μ, 6 to 12 times as long.

In ditches or pools of brackish or fresh water.

170. **Cladophora canalicularis.** (Roth.) Cooke, Algæ, t. 56, f. 5.

Dichotomously or trichotomously branched. Branches connate at the base, often fasciculately branched above, as in *C. glomerata*. Fructiferous cells terminal. Cell-membrane often thick, now and then swollen; cell-contents arranged in very lax spirals. Lower branches 70–180μ, 4 to 8 times as long.

In ditches, pools, and other standing water.

171. **Cladophora ægagropila.** (Linn.) Cooke, Algæ, t. 56, f. 6.

Dark green, threads rigid, very much branched, radiating from a common centre, at length agglomerated into a very dense, spongy globe. Ramuli erect, often quite obtuse. Articulations sometimes incrassated upwards. Cell-contents not in spirals. Cell-membrane now and then thickened. Branches 40–70μ diam., 2 to 4 or even 12 times as long.

**var. Brownii.** (Dillw.)

On stones in streams, etc.

**Family IV. PITHOPHORACEÆ.**

Cladophora-like algæ, consisting of cells formed by bipartition of the terminal cell, the thallus having two distinct parts—the cauloid and rhizoid part. Spores neutral, quiescent, generally cask-shaped, single.

**Genus 64. PITHOPHORA.** Wittr. (1877.)

Character the same as that of the family given above (Fig. 66).
172. Pithophora Kewensis. (Wittr.) Cooke, Algae, t. 56, f. 8-11.

Principal filament of the cauloid part of the thallus 59μ thick, with solitary branches. Spores single, partly enclosed, partly terminal. Enclosed spores cask-shaped, 80μ thick and 200μ long; terminal spores cask-shaped, upper end conical, top somewhat rounded, 38μ thick and 219μ long. The rhizoid part unicellular.
In tank, Water-lily House, Kew Gardens.

**Family V. OEDOGONIACEÆ.**

Monœcious or dioecious. Filaments articulated, either simple or branched. Basal cell obovate-clavate, mostly lobately divided, or ending in a disc. Propagation by zoospores, or by oospores after sexual fecundation. Oogonia single or in a chain (2–5), with a single oospore in each, becoming reddish brown when mature, and dividing into (mostly 4) zoospores. Male plants, dwarf, attached to the female plants, or elongated and similar to the female filaments. Spermatozoids produced in abbreviated special cells.

**Genus 65. OEDOGONIUM. Link. (1820.)**

Articulated filament simple. Cells marked with transverse striæ at one extremity. Terminal cell sometimes setiform. Either monœcious or dioecious; when dioecious the male plants either dwarf—produced from short cells of the female plants—or elongated and independent. Propagation by asexual zoospores, and by oospores sexually fertilized (Fig. 67).
Section 1. Monoeccious species.

A. Oogonia always destitute of median processes.

a. Oospores globose or subglobose.


Oogonia single, very rarely binate, pear-shaped globose, pore a little above the middle. Oospores rather depressed globose, almost filling the oogonium. Spermogonia 1–2 celled, hypogynous or epigynous. Spermatozoids single (?), terminal cell obtuse. Cells 6–7μ, 5 to 7 times as long; oospore 20–23 × 17–19μ.

In pools, etc., Ireland.


Oogonia single, elliptic, or rather depressedly globose, opening by a median pore, almost filling the oogonium. Spermogonia 2–7 celled, scattered. Spermatozoids single (?). Cells 7–9μ, 4 to 6 times as long; oospore 22–23 × 19–21μ.

var. B. vulgar. (Wittr.) Cooke, Algae, t. 68, f. 2.

Oogonia 2–5, continuous or single. Spermogonia 1–4 celled, sub-epigynous or hypogynous, or scattered. Cells 5–8μ, 3 to 5 times as long; oospore 16–22 × 13–18μ.

In pools and ditches.

175. Edogonium curvum. (Prings.) Cooke, Algae, t. 58, f. 3.

Oogonia 2–7 continuous, or single, depressedly globose, opening by a median pore. Oospores depressedly globose, filling the oogonium. Spermogonia 3 or many celled, in the upper part of the filament. Spermatozoids single; upper part of thread arcuate, or spirally twisted. Cells 5–10μ, 1½ to 4 times as long; oospore 20–23 × 16–19μ.

In pools, etc., Ireland.


Oogonia single, rarely binate, rather depressedly globose, opening by a pore at the middle, nearly filling the oogonium.
Membrane of oospore scrobiculate, pits deep and dense. Spermogonia 1–4 celled. Spermatozoids single. Cells 8–10\(\mu\), 4 to 7 times as long; oospore 22–31 × 19–27\(\mu\).

In pools and ditches.


Oogonia single, depressedly globose, splitting round in the middle, opening by a median pore. Oosporic depressedly globose, nearly filling the oogonium. Spermogonia 1–10 celled. Spermatozoids single. Vegetative cells slightly capitate; membrane of vegetative cells and oogonia spirally punctate. Cells 9–13\(\mu\), 3 to 6 times as long; oospore 30–42 × 26–36\(\mu\).

In pools, etc., Ireland.


Oogonia single, obversely egg-shaped or globose, opening with an operculum; fissure narrow. Oosporic globose, not filling the oogonium. Spermogonia bicellular, somewhat epigynous. Cells 10–16\(\mu\), 4\(\frac{1}{2}\) to 6 times as long; oospore 34–38 × 34–39\(\mu\).

In pools and ditches.


Oogonia single, obversely egg-shaped or globose, opening with an operculum; fissure narrow. Oosporic nearly globose, not filling the oogonium. Spermogonia 2–5 celled, hypogynous, or sub-epigynous. Spermatozoids binate; terminal cell obtuse. Cells 12–18\(\mu\), 2 to 4\(\frac{1}{2}\) times as long; oospore 33–46 × 34–46\(\mu\).

In pools and ditches.


Oogonia single, obversely egg-shaped, or globose, or nearly globose, pore above the middle. Oosporic globose, not completely filling the oogonium. Spermogonia 2–4 celled, sub-epigynous or hypogynous. Spermatozoids binate. Cells 20–30\(\mu\), 1\(\frac{1}{2}\)–4 times as long; oospores 35–50 × 35–52\(\mu\).

In pools and ditches.

Oogonia single, ellipsoid; pore above the middle. Oospores globose, not filling the oogonium. Spermogonia usually 2-celled. Spermatozoids binate; supporting cells destitute of chlorophyl. Cells 16μ, 2½ to 6 times as long; oospore 33–45 × 33–45μ.

In pools, etc., Ireland.

b. Oospores ellipsoid or egg-shaped.


Oogonia single, ellipsoid; pore above the middle. Oospores ellipsoid, filling the oogonium (membrane, when mature, longitudinally costate?). Spermogonia 1–8 celled, scattered, usually in the upper portion of the filament. Spermatozoids binate, often born with an oblique division. Cells 15–20μ, 3 to 7 times as long; oospore 36–45 × 54–63μ.

In pools and ditches.

B. Oogonia furnished with verticellate median processes.

a. Oospores subglobose.


Oogonia single, ellipsoid; median processes 7–10, obtusely conical; oogonia splitting below the middle, opening by a pore in the fissure; viewed from above stellate, with 7–10 rays, the depressions between the rays deep and rounded. Oospores globose, not filling the oogonium. Spermogonia 1–2 celled; terminal cell obtuse or apiculate. Cells 8–10μ, 3 to 6 times as long; oospore 22–23 × 22–23μ.

In pools, etc., Ireland, Scotland.

b. Oospores subellipsoid.


Oogonia single, biconically oblong; median processes 9, rounded, small; oogonia deeply cut round; vertical view
orbicular, margin slightly undulated. Oospores ellipsoid, as if constricted in the middle, not filling the oogonium. Spermogonia 1–2 celled, sub-epigynous or hypogynous; terminal cell obtuse; upper part of the filament curved. Cells $3\frac{1}{2} - 5\mu$, 5 to 6 times as long; oospore $9-12 \times 15-18\mu$

In pools, etc., Ireland.


Monoeious. Oospore elliptic, its wall marked by somewhat coarse longitudinal striae, not filling the cavity of the much larger and elliptic oogonium. Aperture of the oogonium very high up, close to the annular striae of the caps.

In pools, etc., Ireland.

**Section II. Diœceous species.**

**A. Dwarf males unicellular.**

a. Oogonia furnished with verticellate median processes.

186. **Oedogonium platygynum.** (*Wittr.*) *Cooke, Algæ*, t. 59, f. 5.

Gynandrosporous. Oogonia single (rarely binate), depressedly obverse egg-shaped; median processes 7–12, rounded; oogonia cut round below the middle; pore in the fissure; vertical view orbicular; margin sinate, with 7–12 (usually 8) depressions. Oospores rather depressedly globose, nearly filling the oogonium. Androsporangia 1–3 celled; terminal cell obtuse. Dwarf males obverse egg-shaped, small, seated on the oogonia. Cells 6–10$\mu$, 2 to 5 times as long; oospores $17-24 \times 15-20\mu$; dwarf males $4\frac{1}{2} - 5 \times 8\frac{1}{2} - 9\frac{1}{2}\mu$.

In pools, etc., Ireland.

b. Oogonia destitute of median processes.

a. Oospores globose or subglobose.


Gynandrosporous. Oogonia single, or 2–6 continuous, globose, or rather depressedly globose; pore at the middle.
INTRODUCTION TO FRESH-WATER ALGÆ.

Oospores rather depressedly globose, almost filling the oogonia. Androsporangia 2–4 celled, sub-hypogynous. Dwarf males obversely egg-shaped, seated on the oogonia. Cells 6–8μ, 3 to 8 times as long; oogonia 20–21 × 16–19μ.

In pools and ditches.

188. Eödogonium Areschougii. (Wittr.) Cooke, Algæ, t. 59, f. 7.

Gynandrosporous. Oogonia 2–6, continuous or single, rather depressedly globose, broadly cut round in the middle; pore in the fissure. Oospore exactly globose, not filling the oogonium. Androsporangia 1–6 celled; terminal cell obtuse. Dwarf males obversely egg-shaped, seated on the oogonia. Cells 8–12μ, 4 to 6 times as long; oospore 22–24 × 22–24μ; dwarf males 6–7 × 14–15μ.

In pools, etc., Ireland.


Idio-androsporous. Oogonia simple, rarely 2–3 continuous, obversely egg-shaped, nearly globose, opening by a terminal operculum. Oospores nearly globose, almost filling the oogonium; terminal cell obtuse; filaments bearing the androsporangia a little slenderer than the female filaments. Androsporangia 6–10 celled. Dwarf males broadly obverse egg-shaped, seated on the oogonia. Cells 18–28μ, equal to three times as long; oospore 32–37 × 31–40μ; dwarf males 10 × 15μ.

190. Eödogonium undulatum. (Breb.) Cooke, Algæ, t. 59, f. 9.

Oogonia single or twin, ellipsoid-globose, or nearly globose; pore below the middle. Oospore ellipsoid-globose or nearly globose, nearly filling the oogonia; vegetative cells four times undulatingly constricted; terminal cell obtuse; dwarf males obconical, seated on the supporting cells. Cells 15–17μ, 3 to 5 times as long; oospores 46–50 × 48–60μ; dwarf males 9–10μ long.

In pools, etc., Scotland.


Mr. Roy has announced that the Cymatomena figured by Reinsch (Contrib. t. 6, f. 7) has been found in Scotland,
and is a genuine *Edogonium*, but no further details have transpired, and we know nothing of the fructification.

**B. Dwarf males bicellular, spermogonia internal.**


Gynandrosporous. Oogonia single, depressedly globose; pore at the middle. Oospores depressedly globose, not filling the oogonia. Androsporangia 2-celled. Dwarf males oblong, obversely egg-shaped, one-third shorter than the oogonia on which they are seated. Cells 8–9μ, 3 to 6 times as long; oogonia 28 × 26μ; oospores 23 × 17μ.

In pools, etc., Scotland.

**C. Dwarf males bi-multicellular, spermogonia external.**

* Oospores with smooth membrane.

a. Oospores globose or subglobose.


Idio-androsporous. Oogonia single, egg-shaped globose; pore a little above the middle. Oospores globose, not filling the oogonia. Androsporangia 1–9 celled. Dwarf males a little curved, seated on the supporting cell. Spermogonia 1 (or 2?) celled. Cells 18–21μ by 4½ to 6 times as long; oospor 45–49 × 45–49μ.

In pools and ditches.


In pools, etc.


Oogonia single or twin (rarely 3), obversely egg-shaped or globosely egg-shaped, opening by an operculum,
with a very narrow fissure. Oospores globose or egg-shaped, not filling the oogonia; terminal cell shortly apiculate. Dwarf males much curved, seated on the oogonia. Spermogonia many (to 7) celled. Cells 15–16, 3 to 5 times as long; oospores 31–34 × 33–39.

In pools and ditches.


Gynandrosporous. Oogonia single or twin, globose egg-shaped or nearly globose; pore above the middle. Oospores ellipsoid-globose or globose; membrane very thick, almost filling the oogonia. Androsporangia 2–5 celled. Dwarf males nearly straight, seated on or about the supporting cells. Spermogonia 1 (?) celled. Cells 27–30, 3 2 to 5 times as long; oospores 51–57 × 52–63.

In pools and ditches.

b. Oospores ellipsoid or egg-shaped.


Gynandrosporous. Oogonia single or twin, obversely egg-shaped; pore above the middle. Oospores obversely egg-shaped, almost filling the oogonia; supporting cells swollen. Androsporangia 2 (?) celled; terminal cell obtuse. Dwarf males a little curved, seated on the supporting cells. Spermogonia unicellular. Cells 15–21, 3 to 5 times as long; supporting cells twice as long; oospores 40–44 × 51–54.

In pools and ditches.


Gynandrosporous. Oogonia 2–6 continuous, or single, egg-shaped, or quadrangularly ellipsoid; pore above the middle. Oospores filling the oogonia. Sporoderm delicately porose; supporting cell swollen. Androsporangia 2–4 celled; terminal cell obtuse. Dwarf males curved, seated on the supporting cells. Spermogonia 2–4 celled. Cells
25-10μ, 3 to 10 times as long; supporting cells 2\frac{1}{2} times as long; oospores 65-76 × 87-95μ.

In pools and ditches.

199. **Edogonium acerosporum.** (De Bary.) Cooke, Algæ, t. 61, f. 2.

Idio-androsporous. Oogonia solitary, terminal, ellipsoid, opening by a small apical deciduous operculum. Oospore filling the oogonia; membrane longitudinally costate. Supporting cells often swollen; terminal cells obtuse. Dwarf males curved, seated on the supporting cells. Spermogonia 1-2 celled. Cells 10-14μ, 2 to 7 times as long; supporting cells 2 to 3 times as long; oogonia 30-35 × 45-51μ.

In pools and ditches.

200. **Edogonium eiliatum.** (Hass.) Cooke, Algæ, t. 61, f. 3.

Gynandrosporous. Oogonia 2-7, continuous or single, egg-shaped, opening by an operculum, with a broad fissure. Oospores egg-shaped, nearly filling the oogonia. Androsporangia 2-8 celled; terminal cell setiform. Dwarf males curved, seated on the oogonium. Spermogonia unicellular. Cells 15-23μ, 2\frac{1}{2} to 4 times as long; oospore 40-46 × 47-57μ.

In pools and ditches.

** Membrane of oospore echinulate. Oospores globose.

201. **Edogonium Cleveanum.** (Witt.) Cooke, Algæ, t. 62, f. 1.

Gynandrosporous. Oogonia single, subglobose; pore below the middle. Oospores almost filling the oogonium, globose, spinulose; spines conical, spirally disposed. Androsporangia 4-6 celled. Dwarf males a little curved, seated on the supporting cell. Spermogonia unicellular. Cells 18-26μ, 3 to 7 times as long; oospores 49-57 × 51-59μ; spines 4μ long.

In pools and ditches, Ireland.

202. **Edogonium echinospermum.** (Br.) Cooke, Algæ, t. 62, f. 2.

Gynandrosporous, or idio-androsporous. Oogonia single, ellipsoid-globose, or nearly globose; pore at the middle.
Oospore almost filling the oogonia, globose, echinulate; spines awl-shaped. Androsporangia 2–5 celled. Dwarf males a little curved, seated on the supporting cells. Spermogonia unicellular. Cells 18–3μ, $2\frac{1}{2}$ to $4\frac{1}{2}$ times as long; oospore 38–47 × 38–49μ; spines 3μ long.

In pools and ditches.

**Sub-section ii.** Dioecious, with elongated male plants.

**a. Oogonia not, or scarcely, swollen.**

203. *Edogonium capillare.* (Linn.) Cooke, Algæ, t. 62, f. 3.

Oogonia single, not swollen, cylindrical; pore above the middle. Oospores globose or cylindrical-globose, not filling the oogonia. Male plants the same, or almost the thickness of the female plants. Spermogonia 1–4 celled, alternate with the vegetative cells. Spermatozoids binate. Cells 35–55μ, equal or twice as long; oospore 30–52 × 39–63μ.

In pools and ditches.

204. *Edogonium capilliforme.* (Kutz.) Cooke, Algæ, t. 129, f. 4.

Oogonia single, a little swollen, obversely egg-shaped, with a superior pore. Oospores ellipsoid-globose or cylindrically globose, not filling the oogonia. Male plants more slender than the females. Spermogonia 2–10 celled, alternating with the vegetative cells; terminal cell obtuse. Cells of female 30–34μ, $1\frac{1}{2}$ to 3 times as long; of male 24–28 mm., $1\frac{1}{2}$ times as long; oospore 37–45 × 40–50μ.

In pools and ditches.

**b. Oospores manifestly swollen.**

**aa. Oospores globose, or nearly so.**


Oogonia single (very rarely twin), depressedly globose; pore at the middle. Oospores filling the oogonia. Male plants the same, or almost the same, thickness as the female. Spermogonia 2–5 celled. Spermatozoids single (?). Cells 11–14μ, 2 to 4 times as long; oospore 26–28 × 20–21μ.

In pools and ditches.

Oogonia single, between heart-shaped and globose; pore a little above the middle. Oosporae globose, not filling the oogonia. Male plants slenderer than the female. Spermodogonia 2–10 celled. Spermatozoids binate; terminal cells obtuse. Cells: fem. 18–30μ, 2–7 times as long; male 15–25μ, 2 to 6 times as long; oospore 42–60 × 42–60μ.

In pools and ditches.


Oogonia single or twin, obversely egg-shaped—or ovate—globose; pore above the middle. Oosporae nearly globose, scarce filling the oogonia. Male plants slenderer than the female. Spermodogonia 2–5 celled. Spermatozoids binate; terminal cell obtuse. Cells: fem. 16–30μ, 3 to 6 times as long; male 14–16 mm., 3 to 6 times as long; oospore 42–50 × 46–56μ.

In pools and ditches.


Oogonia single or 2–6 continuous, somewhat egg-shaped globose, opening by an operculum, with a very narrow fissure. Oosporae globose, not filling the oogonia. Male plants slenderer than the female. Spermodogonia 2–10 celled, alternate with the vegetative cells in the upper part of the filament; terminal cell obtuse or rarely shortly apiculate. Cells: fem. 12–20μ, 2 to 4 times as long; male 11–16 mm. 2 to 4 times as long; oospore 28–35 × 28–34μ.

In pools and ditches.


Oogonia single, depressedly globose, manifestly splitting round in the middle; pore in the fissure. Oospore depressedly globose, nearly filling the oogonia. Male plants slenderer than the female. Spermodogonia 3–7 celled. Spermatozoids single. Membrane of the vegetative cells and oogonia spirally punctate; basal cell depressedly globose; membrane vertically plicate. Cells: fem 18–22μ, 2 to
6 times as large; male 16–19μ, 2 to 6 times as long; oospore 44–51 × 35–43μ.
In pools and ditches, Ireland.

bb. Oospores ellipsoid or egg-shaped.

210. **Edogonium Boseii.** (Le Clerc.) Cooke, Algæ, t. 63, f. 4.

Oogonia single, rarely twin, oblong-ellipsoid; pore above the middle. Oospores ellipsoid, by no means filling the oogonia, longitudinally costate. Male plants the same, or nearly the thickness of the female. Spermogonia 3–6 celled. Spermatozoids binate; terminal cell slenderer and somewhat hyaline. Cells 14–20μ, 4 to 6 times as long; oospore 36–40 × 60–65μ.
In pools, etc.

211. **Edogonium tumidulum.** (Kutz.) Cooke, Algæ, t. 63, f. 5.

Oogonia single, ellipsoid egg-shaped; pore above the middle, almost filling the oogonium. Male plants a little slenderer than the female. Spermogonia 6–45 celled. Spermatozoids binate. Cells: fem. 18–25μ, 3½ to 5 times as long; male 15–18μ, 4 times as long; oospore 49–54 × 61–68μ.
In pools and ditches, Ireland.

212. **Edogonium Landsboroughii.** (Hass.) Cooke, Algæ, t. 64, f. 1.

Oogonia single, rarely twin, obversely egg-shaped; pore above the middle. Oospores obversely egg-shaped, filling the oogonia (or rarely ellipsoid and not filling the oogonia). Male plants slenderer than the female. Spermogonia 5–25 celled. Spermatozoids binate, with a vertical division; terminal cell obtuse. Cells: fem. 33–36μ, 4 to 6 times as long; male 31–33μ, 4 to 6 times as long; oospore 57–70 × 75–100μ.
In pools and ditches.

*var. b.* gemelliparum. (Prings.) Cooke, Algæ, t. 64, f. 2.
Smaller than the typical form. Oogonia egg-shaped. Oospores filling the oogonia; terminal cell very long,
somewhat hyaline. Cells: fem. 20-27μ, 3 to 5 or 8 times as long; oospore 49-51 × 65-69μ.

In pools and ditches, Ireland.

213. Oedogonium rivulare. (Le Clerc.) Cooke, Alge, t. 61, f. 3.

Oogonia single, or 2-7 continuous, obversely egg-shaped; pore above the middle. Oospores obversely egg-shaped, rarely ellipsoid or nearly globose, not filling the oogonia. Male plants slenderer than the female. Spermodonia 3-9 celled. Spermatozoids binate. Cells: fem. 40-45 mm., 3 to 8 times as long; male 30-36μ, 4 times as long; oospore 55-70 × 65-100μ.

In pools and ditches, Scotland.

Sub-section 3. Species of which fructification imperfectly known.

a. Oospores globose or subglobose

214. Oedogonium delicatulum. (Kutz.) Cooke, Alge, t. 66, f. 7.

Pallid. Basal cell scarcely lobed at the base, affixed. Cells cylindrical. Oogonia subglobose, inflated, a little extended at either pole. Oospore perfectly globose. Cells 5-6μ, 3 times as long; oospores 12-14μ.

In pools, etc., Deeside (Scotland).


Basal cell 2 to 3 lobed, at first fixed; terminal joint obtuse. Cells cylindrical or rather clavate. Oogonia very much inflated. Oospore globose, bright orange. Cells 9-11μ, 4 to 8 times as long; oospore 16-18μ.

In pools, etc., Deeside (Scotland).

216. Oedogonium hexagonum. (Kutz.) Cooke, Alge, t. 66, f. 8.

Oogonia almost globose. Oospores globose, rufous-brown, not filling the oogonia. Basal cell bifurcate; terminal cell often setigerous. Cells 11-13μ, 2 to 4 times as long; oospore 16μ.

In pools, etc., Deeside (Scotland).
INTRODUCTION TO FRESH-WATER ALGÆ.

217. Edogonium Londinense. (Witr.) Cooke, Algæ, t. 65, f. 4.

Monœcious (?) Oogonia twin or single, globose, cut round (circumscissile) in the middle, pore seated in the fissure. Oospores globose, almost filling the oogonia. Spermogonia (or androsporangia ?) 1–2 celled, hypogynous. Cells 10–15μ, 1½ to 5 times as long; oospore 27–32 x 27–32μ.

In pools, etc.

218. Edogonium fasciatum. (Kutz.) Cooke, Algæ, t. 66, f. 2.

Oogonia somewhat globose. Oospores globose, rufous-brown, almost filling the oogonia. Basal cell usually bilobate; terminal cell obtuse. Cells 28–30μ, twice as long; oospore 30–32μ.

In pools, etc., Deeside (Scotland).

219. Edogonium capillaceum. (Kutz.) Cooke, Algæ, t. 66, f. 3.


In pools, etc., Deeside (Scotland).


Oogonia single, rather depressedly to somewhat egg-shaped, globose; pore above the middle. Oospores filling the oogonium; epispore punctate with little warts; supporting cells swollen. Cells 30–35μ, 4 to 6 times as long; oospores 60–73 x 55–72μ; supporting cells 2 to 4 times as long.

In pools, etc., Ireland.

221. Edogonium princeps. (Hass.) Cooke, Algæ, t. 65, f. 2.

Oogonia single, somewhat egg-shaped globose; pore above the middle. Oospores globose, not distinctly filling the oogonium. Cells 37–45μ, 1½ to 2½ times as long; oospore 58–66 x 60–65μ.

In pools and ditches.
b. Oospores subelliptic or oval.

222. *Odogonium longatum.* (Kutz.) Cooke, *Algae*, t. 64, f. 4.

Oogonia single (often solitary, terminal), rarely 2–3 continuous, ellipsoid, opening by an operculum, with a narrow fissure. Oospores globose-ellipsoid, scarcely filling the oogonium; terminal cell obtuse. Cells 5–6 μ, 2 to 3 times as long; oospores 15–16 × 17–18 μ.

In pools and ditches.


Oogonia single, ellipsoid, globose, opening by an operculum, with a narrow fissure. Oospores ellipsoid-globose, almost filling the oogonium. Cells 17–21 μ, 1 1/4 to 3 times as long; oospore 37–38 × 41–42 μ.

In pools, etc., Scotland.


Oogonia oval-elliptic, nearly twice as long as broad. Oospores oval-elliptic, entirely filling the oogonia. Basal cell contracted towards the base, then dilated and discoid; terminal cell obtuse. Cells 25–35 μ, 3 to 4 or 5 times as long; oospore 90 × 65 μ.

In pools, etc., Scotland.


Oogonia single, a little swollen, cylindrically egg-shaped; pore above the middle. Oospores cylindrically ellipsoid, nearly filling the oogonia (or flask-shaped and filling the oogonia). Epispore delicately scrobiculate; supporting cells rather swollen. Cells 30–24 μ, 2 to 4 1/4 times as long; supporting cells 1 1/2 to 1 3/4 times as long; oospore 54–65 × 75–103 μ.

In pools, etc.


Oogonia single (rarely twin), obversely egg-shaped ellipsoid, a little swollen; pore above the middle. Oospores
INTRODUCTION TO FRESH-WATER ALGÆ.

ellipsoid, not filling the oogonia. Cells 33–55μ, 2 to 5 times as long; oospore 60–66 × 80–110μ.

In pools, etc.

227. Ædogonium subsetaceum. (Kutz.) Cooke, Alga, t. 66, f. 5.

Basal cell dilated and discoid at the base, rather lobed; terminal joint obtuse. Oospores broadly oval, golden red, closely involved in the oogonium. Cells 40–52μ, equal or twice as long; oospore 60 × 50μ.

In pools, etc., Deeside (Scotland).

Genus 66. BULBOCHÆTE. Ag. (1817.)

Filaments articulated, branched, joints thickened upwards, at or about the apex bearing setæ, straight, hyaline; bulbous at the base. Cell-membrane usually punctate. Oogonia opening by a lateral pore above the middle. Mature oospore red. Monoecious or dioecious. Reproduction sexual, as in Ædogonium (Fig. 68).

Section 1. Oogonia globose or subglobose; dioecious.

B. Dwarf males bicellular.

228. Bulbochæte intermedia. (De Bary.) Cooke, Alga, t. 67, f. 1.

Oogonia depressedly globose, seated beneath the androsporangia; dissepiment of supporting cell in the middle. Epispore delicately crenulate. Androsporangia 1–2 celled, epigynous, rarely scattered. Dwarf males seated on the oogonia. Stem slightly curved. Cells 17–19μ, 1\frac{1}{2} to 3 times as long; oogonia 40–48 × 31–40μ; dwarf males 9–10 × 24–26μ.

In ditches, etc.

229. Bulbochæte polyandra. (Cleve.) Cooke, Alga, t. 67, f. 2.

Idio-androsporous. Oogonia sub-depressedly globose, seated beneath terminal setæ or vegetative cells; dissepiment of supporting cell above, or about the middle. Epispore delicately crenulate or nearly even. Andro-
sporangia 4–10 celled. Dwarf males seated on the oogonia. Stem a little curved. Cells 15–20μ, 3 to 5 times as long; oogonia \(35-46 \times 32-38\mu\); dwarf males \(8-9 \times 23\mu\).

In ditches, etc.

230. Bulbochæte Brebissonii. (Kutz.) Cooke, Algæ, t. 67, f. 3.

Oogonia obcordate-globose, truncate below, erect, seated beneath terminal setæ or androsporangia; dissepiment of supporting cell low. Epispore delicately crenulate. Androsporangia 2–3 celled, scattered or epigynous. Dwarf males seated on the oogonia, rarely around it. Stem straight, or nearly so. Cells \(17-20\mu\) by 3 to \(4\frac{1}{2}\) times as long; oogonia \(42-50 \times 37-45\mu\); dwarf males \(10-12 \times 28-33\mu\).

In pools, etc.

231. Bulbochæte setigera. (Ag.) Cooke, Algæ, t. 68, f. 1.

Oogonia depressedly globose, seated beneath terminal setæ, or androsporangia. Membrane of the oogonium after fertilization thickened; dissepiment of supporting cell a little above the middle. Epispore granulated. Androsporangia bicellular. Dwarf males upon or about the oogonia. Stem straight. Cells \(25-28\mu\), \(2\frac{1}{2}\) to 5 times as long; oogonia \(75-80 \times 60-65\mu\); dwarf males, \(12-13 \times 34-36\mu\).

In pools and ditches.


Idio-androsporous (?) Oogonia obcordate-globose, seated beneath terminal setæ, rarely beneath vegetative cells; dissepiment of supporting cell at or a little above the middle. Epispore verrucose. Dwarf males a little longer than the oogonia, and seated upon it. Stem twice as long as the spermogonium, arcuate. Cells \(24-27\mu\), by 2 to 3 times as long; oogonia \(62-66 \times 51-58\mu\); stem of dwarf males \(11-12 \times 40-45\mu\).

In pools and ditches.
Section 2. Oogonia ellipsoid or subellipsoid.

Sub-Section 1. Species monœcious.


Oogonia ellipsoid, or rather oblong-ellipsoid, patent, or rarely erect, seated beneath terminal setæ or vegetative cells. Spermogonia 2–4 celled, erect (rarely patent), subepigynous, or scattered. Cells 16–20μ, $\frac{1}{4}$ to $\frac{3}{4}$ times as long; oogonia 27–35 × 46–56μ.

In pools and ditches.

Sub-Section 2. Species dioecious.


Oogonia ellipsoid, patent, seated beneath terminal setæ or vegetative cells, in longitudinal section rather quadrangular. Androsporangia scattered. Dwarf males seated about the oogonia. (Filament at first short, and curved.) Cells 12–15μ × a third part shorter or equal; oogonia 23–25 × 34–40μ.

In ditches, etc.


Oogonia ellipsoid, patent or erect, seated beneath androsporangia or terminal setæ. Epispore delicately transversely striate. Androsporangia epigynous, or rarely scattered. Dwarf males seated about or upon the oogonia. Cells 20–25μ, $2\frac{1}{3}$ to $4\frac{1}{3}$ times as long; oogonia 46–50 × 70–100μ; stem of dwarf males 17–19 × 29–31μ.

In pools, etc., Ireland.

236. Bulbochæte rectangularis. (Wittr.) Cooke, Algæ, t. 67, f. 3.

Oogonia ellipsoid, patent, or rarely erect, seated beneath terminal setæ, or androsporangia, or vegetative cells. Androsporangia scattered or epigynous. Vegetative cells somewhat rectangular in longitudinal section. Branches few and very long. Dwarf males seated about or upon
the oogonia. Cells 19–23\(\mu\), 1\(\frac{1}{4}\) to 2 times as long; oogonia 30–39 \(\times\) 48–55\(\mu\); stem of dwarf males 15–18 \(\times\) 22–27\(\mu\).
In pools, etc., Ireland.

Section 3. Species of which fructification imperfectly known.


Monoecious (?). Oogonia oblong-ellipsoid, patent or rarely erect, with vegetative cells above; supporting cells without dissepiment (?). Cells 13–14\(\mu\), 1\(\frac{1}{4}\) to 1\(\frac{1}{2}\) times as long; oogonia 21–24 \(\times\) 49–54\(\mu\).
In pools, etc., Ireland.

Family VI. Ulotricheæ.

Aquatic or terrestrial, green or yellowish green. Threads very shortly articulate, simple, very rarely dividing into single branches, free, now and then laterally connate in bands. Primitive cells always many times longer than their diameter; after repeated division equal, or shorter; all fertile. Cell-membrane sometimes very thick, and distinctly lamellose. Cell-contents at first effused, after division transmuted into gonidia. Gonidia of two kinds, produced within the cells of the threads, emitted either by a poriform opening, or by the breaking up of the mother-cell.

Genus 67. Hormiscia. Ares. (1866.)

Articulate thread fixed by the basal cell, attenuated downwards; simple, or now and then emitting branchlets. Cells abbreviated, with a thick cell-membrane, often lamellose. Cell-contents green. Propagation by macrogonidia and microgonidia (Fig. 69).

Pale green, more or less crispate. Cells equal or a little shorter than their diameter. Cell-membrane thick, colourless, somewhat lamelllose, more or less constricted at the septa. Cells 11–14 μ diam.

In swamps, amongst *Sphagnum*, etc.


More or less bright green, mucous, 2 or 3 feet long, often less, either floating or interwoven. Sterile cells equal, or half their diameter; fructiferous cells usually a little longer than broad. Cell-membrane thick, slightly constricted at the septa. Cells 12–40 μ; macrozoospores 12–18 × 10–12 μ; microzoospores 5–10 × 4–7 μ.

In ditches, ponds, swamps, etc.


Yellowish green. Cells equal, or a little longer than their diameter. Cell-membrane rather thick.

*var. catenæformis.* (Kutz.) Cooke, *Algæ*, t. 70, f. 2.

Rather thicker than in the typical form. Cells a little longer than their diameter. Cell-membrane thick, striate, manifestly constricted at the septa. Cells 12–18 μ diam.

In ditches and streams, attached to aquatic plants.


Dark green, 1–2 inches long. Threads often crispate. Cells 2 to 4 times shorter than their diameter; fructiferous cells subglobose. Cells 43–48 μ diam.

In brackish and fresh water.


Bright green. Tufts very long, 1 foot or more. Articulations 2 to 3 times shorter than their diameter, pectinate. Cell-membrane thick, distinctly lamelllose. Cells 5 μ diam.

In fresh water.
Genus 68. **ULOTHRIX.** Kutz. (1845.)

Threads articulate, simple. Articulations short, sometimes shorter than their diameter, rarely a little longer. Cell-membrane thin, very rarely lamelllose. Cell-contents effused, green (Fig. 70).


Pale green. Cells equal, or a little longer than their diameter, rarely twice as long. Cell-contents at first always contracted in a quadrate manner. Cells 5–7μ.
In ditches and slow streams.

244. Ulothrix tenerrima. (Kutz.) Cooke, *Algæ,* t. 70, f. 5.

Pale green or yellowish green, lubricous. Cells mostly equal in length and diameter, now and then a little shorter. Cells 7–10μ.
In ditches, turbaries, etc.


Dark green, attached, from ½ to 2 or 3 inches long, mucous. Cells equal, or 2 to 4 times shorter than their diameter. Cell-membrane thin, homogeneous. Cells 17–26μ.
In ditches and streamlets.


Yellowish green, rather rigid, densely interwoven in a soft velvety green stratum. Cells either nearly equal or 2 to 3 times shorter than their diameter. Cells 7½–9½μ.
On the naked ground, rocks, walls, etc.


On walls, trunks, etc.
Genus 69. Schizogonium. Kutz. (1843.)

Threads as in Ulothrix, or in many places laterally connate, or by cellular division in two directions forming narrow flat bands, which are more or less crispate (Fig. 73).

248. Schizogonium murale. (Kutz.) Cooke, Algae, t. 71, f. 3.

Dark green, forming a broadly expanded soft velvety stratum. Threads sometimes free, here and there 2 or 3 united. Cells 2 to 4 times shorter than their diameter, pectinate, often crowded, sometimes interrupted. Cell-membrane rather thick, colourless, slightly undulated and constricted. Cells 15–18 μ.

On moist walls and naked ground.

Family VII. Chroolepideæ.

Aerial algae, coloured golden yellow, etc., when dry often becoming greenish grey; more or less fragrant. Threads articulate, branched. Cell-membrane thick, firm, collected in minute tufts, or densely interwoven in a tomentose stratum. Cell-contents oily, red, orange, or yellow brown. Propagation by zoogonidia, produced in proper cells. Zoogonidia oblong-oval, with two vibratile cilia.

Genus 70. Chroolepus. Ag. (1824.)

Characters the same as given above for the family (Fig. 72).

249. Chroolepus aureus. (Linn.) Cooke, Algae, t. 72, f. 1.

Golden red or orange. Threads either collected in small tufts, or spreading in a soft silky stratum, sometimes intricate and very much branched. Cells as long, or 2
to 3 times as long as their diameter. Cells 10–12μ diam.; zoosporangium 20–30μ.
On walls, rocks, chips, bark, etc.

Stratum thin, rather tomentose, rufous-tawny (when dry, cinereous). Threads and branches abbreviated, erect, parallel, flexuously curved, torulose. Cells equal, or twice as long as their diameter. Cells 20–25μ diam.
On the bark of various trees.

Stratum thin, or a line thick, reddish orange, glaucous or dirty greenish when dry. Threads and branches elongated, rather dichotomous, variously curved, ascending. Cells 1½ or 3 times as long as their diameter, in the upper portion of the branches reaching to double that proportion. Cells 25–40μ diam.; zoosporangium 50μ diam.
On rocks, in moist places.

Filaments erect, alternately branched, forming tufts of a permanent tawny yellow. Cells nearly as long as broad, about 30μ diam.
On holly bark.

Stratum thin, crustaceous, rather pulverulent, reddish brown, growing pale when dead. Threads and branches abbreviated, torulose. Joints nearly as long as broad, broadly elliptic or subglobose. Cells 20μ diam.
On the bark of beech and oak.

254. *Chroolepus lichenicolus.* (Ag.) Cooke, *Alga*, t. 72, f. 3.
Tufts red orange. Threads erect, tufted, alternately branched, rigid. Cells slightly tumid, as long as broad. Cells 12μ diam.; zoosporangium about 15μ diam.
On lichens and old trees.
FAMILY VIII. CHÆTOPHORACEÆ.

Aquatic, rarely terrestrial, monœcious or dioœcious. Articulate filaments, often dichotomously, not rarely fasciculately branched, accumulated in tufts, nestling in a fluid or gelatinous mucus, or constituting a filamentose, rarely a somewhat foliaceous thallus. Propagation by oospores after sexual fecundation, or by zoogonidia.

Genus 71. Microthamnion. Näg. (1849.)

Articulate filament dichotomously or trichotomously branched, straight, with the terminal cell obtuse, or nearly so, afterwards swollen, forming a sporangium. Cell-contents effused. Propagation by zoogonidia (Fig. 71).

255. Microthamnion vexator. Cooke, Algæ, t. 73, f. 1.

Filaments erect, very slender, dichotomously branched, more or less growing in tufts. Cells cylindrical, longer than broad, not at all constricted at the joints. Dissepiments scarcely visible. Cell-membrane thin, pellucid. Cells about $3\mu$ diam.

Attached to aquatic plants in clear springs, etc.

Genus 72. Stigeoclonium. Kutz. (1843.)

Articulate threads branched. Branches scattered, rarely approximate in a fasciculate manner, acute at the apex, sometimes attenuated into a colourless bristle; at times extended very long, at other times furnished with shortly subulate branches. Cell-membrane very thin. Cell-contents with the chlorophyll arranged in transverse bands. Propagation by oospores or zoogonidia, each zoospore with four vibratile cilia (Fig. 75).
256. Stigeoclonium thermale. (Braun.) Cooke, Algæ, t. 73, f. 2.

Bright green, branched in a fasciculate manner, creeping at the base. Branches attenuated upwards to the cuspidate apex. Branchlets for the most part alternate, rather remote, nearly erect, setiform. Joints variable, at the base of the filaments equal or twice as long as the diameter, in the upper part of the branchlets 3 to 5 times as long as the diameter. Chlorophyl bands broad, sometimes effused. Cells 12μ.

In thermal springs, etc.

257. Stigeoclonium tenue. (Ag.) Cooke, Algæ, t. 73, f. 3.

Bright green, lubricous. Filaments a little branched. Branches nearly simple. Cells equal, or 2 to 3 times as long as their diameter, more or less constricted. Chlorophyl bands narrow. Branchlets scattered, shortened, nearly erect, subulate. Cells at the base longer than broad, abbreviated towards the apex. Cells 10μ diam.

In streams and ditches.

258. Stigeoclonium protensum. (Dillw.) Cooke, Algæ, t. 74, f. 1.

Pale green, cespitose, slender. Filaments and branches long drawn out. Cells almost cylindrical, equal or twice as long as their diameter; terminal cell extended into a colourless bristle. Branches usually scattered, rarely in pairs, with the extremities cuspidate, piliferous. Cells 15μ diam.

In slow streams.

259. Stigeoclonium nanum. (Dillw.) Cooke, Algæ, t. 74, f. 2.

Filaments alternately branched. Branches abbreviated, a little attenuated upwards, obtuse, not piliferous. Cells equal or a little shorter than their diameter, in the upper part equal. Cells 8μ diam.

In streams.
272 INTRODUCTION TO FRESH-WATER ALGÆ.

260. Stigeoclonium fastigiatum. (Ralfs.) Cooke, Algæ, t. 74, f. 3.

Pale green, small. Thread very much branched, fastigate, radiately disposed, mucous. Upper branches alternate, fastigate, moniliform, somewhat pinnate, a little spreading, extended at the apex in a long bristle. Cells of the filament three times as long as broad; of the branches, equal or twice as long, swollen, constricted at the joints. Cells 12µ diam.

Attached to aquatic plants.

Genus 73. DRAPARNALDIA. Ag. (1824.)

Articulate thread simply branched, formed of large cells, for the most part hyaline, with a broad chlorophyllose band; more or less densely furnished with penicellate fasciculate branchlets, alternate or opposite, composed of smaller fertile cells. Terminal cells hyaline and more or less elongated into a bristle. Propagation by resting spores or zoogonidia (Fig. 74).

261. Draparnaldia glomerata. (Ag.) Cooke, Algæ, t. 75, f. 1.

Filaments and primary branches colourless, or nearly so. Lower cells equal, or a little shorter than their diameter, distinctly constricted at the joints. Chlorophyllose bands narrow, pale green. Primary branches spreading at right angles, sometimes opposite; fascicles of the branches crowded, alternate or opposite, densely branched, obtuse, oval. Cells of main thread 35µ; of fascicles 8µ.

In clear pools or slow streams.

262. Draparnaldia plumosa. (Vauch.) Cooke, Algæ, t. 76, f. 1.

Threads and primary branches hyaline. Cells equal or shorter than their diameter, scarcely constricted at the joints. Chlorophyllose bands narrow, bright green. Lower cells of the branches equal, or almost twice as long as their diameter; upper cells cylindrical, attenuated, 2 to 5 times as long as broad, sometimes not piliferous. Fascicles of the
branches densely branched, elongated, with an acutely lanceolate outline, erect, somewhat appressed. Cells of main thread 45μ; of fascicles 8μ.

In slow streams or pools.

**Genus 74. CHÆTOPHORA. Schrank. (1789.)**

Articulate filaments, with the primary branches radiately disposed, composed of elongated vegetative cells, with chlorophyl bands; divided upwards into numerous branchlets, which are shortly articulated, the ultimate joint attenuated, scarcely lengthened into a thread. Ultimate branchlets in fascicles, involved in a firm gelatinous mass, of a globose, expanded, or variously lobed form. Propagation as in the preceding (Fig. 84).


Thallus globose, about the size of a pea, often smaller (now and then as large as a cherry), bright green, even, shining, sometimes aggregated, not rarely confluent. Cells 6–9μ; of branches 6μ.

On submerged plants.


Thallus subglobose, the size of a cherry, bright or pale green. Surface tuberculose, elastic. Fascicles of branches very dense. Lower articulations cylindrical; the upper swollen. Extremities cuspidate, sharp pointed, rarely hair-like. Cells 9–12μ; of branches 8–10μ.

In clear water.


Thallus the size of a pea or a cherry, pale green. Surface even, elastic, soft, now and then becoming hard. Fascicles of branches lax, rather flaccid. Extremities shortly cuspidate, often terminating in a hair. Cells 7–9μ; of branches 5–7μ.

In clear water, attached to submerged plants.
INTRODUCTION TO FRESH-WATER ALGÆ.

266. Chaetophora endivæfolia. (Ag.) Cooke, Algæ, t. 78, f. 2.

Thallus linear, flattened, \( \frac{1}{3} \)-1 inch, bright green, dichotomously laciniate. Threads and primary branches mostly colourless, here and there with green zones, parallel. Fascicles of branches lateral, more or less dense. Spreading articulations more or less swollen, nearly equal in length and diameter, constricted at the joints. Cell-contents effused. Cells 10-15\( \mu \); of branches 8-11\( \mu \).

In ditches, etc.

Genus 75. COLEOCHÆTE. Breb. (1844.)

Articulated filaments branched, either united in a pulvinule, or little cushion, or expanded in a flat, somewhat disc-shaped thallus. Cells oblong, more or less dilated in front, sometimes bearing from the back or upper surface a hyaline bristle, sheathed at its base. Propagation by oospores and by zoogonidia (Fig. 85).

267. Coleochæte soluta. (Prings.) Cooke, Algæ, t. 78, f. 3.

Threads radiating from a common centre, furcately branched, of equal length, closely packed side by side, prostrate, but not connate, forming an orbicular disc. Cells 1\( \frac{1}{2} \) to 3 times as long as broad. Oogonia placed before the terminal cells, globose, corticate. Cells 25\( \mu \).

Attached to aquatic plants.

268. Coleochæte scutata. (Brebul.) Cooke, Algæ, t. 79.

Filaments and their branches radiating from the centre, very densely connate in one stratum, forming a kind of parenchymatous orbicular disc. Cells quadrangular, nearly equal or twice as long. Oogonia subglobose, peripherical, corticate above, naked below. Cells 20-22\( \mu \).

On aquatic plants.

269. Coleochæte orbicularis. (Prings.) Cooke, Algæ, t. 80, f. 1.

Disc orbicular, parenchymatous, formed from one stratum of cells, bright green. Cells oblong-quadrangular when
old, by pressure becoming often polygonal, usually twice as long as broad. Oogonia oval, peripheral, mostly naked. Cells 12–17μ.

On aquatic plants.

Genus 76. Aphanochæte. *Braun.* (1847.)

Articulate threads prostrate, somewhat creeping, sometimes united in an irregular stratum. Branches decumbent or ascending. Cells bearing on their apex or back often a long bristle which has no sheath at the base. Propagation by zoogonidia (Fig. 83).

270. Aphanochæte repens. *(Braun.)* Cooke, Algae, t. 80, f. 3.

Filaments and branches procumbent, adpressed. Cells slightly swollen, of equal diameter in both directions, supporting an indistinctly articulated bristle. Cells 5–10μ.

On *Cladophora flavescens*, and other algae.

271. Aphanochæte hystrix. *(Thw.)* Cooke, Algae, t. 80, f. 2.

Filaments and their branches radiating, procumbent, adpressed, more or less connate in a pale green irregular discoid thallus. Cells somewhat cylindrical, produced at the apex into a long bristle, which is not articulated. Cells 10μ diam.

On aquatic plants in brackish ditches.

The family Chytridieæ are too uncertain to be included here. They are parasitic, and, as some contend, more allied to fungi than algae.
276 INTRODUCTION TO FRESH-WATER ALGÆ.

Class II. PHYCOCHROMOPHYCEÆ.

One or many celled, living in water, or enclosed in a maternal jelly when out of it, mostly in families formed from successive generations of cells. Cell-contents brown, olivaceous, or fuscous. Propagation by division and by immovable gonidia.

ORDER I. CYSTIPHORÆ.

Unicellular. Cells spherical, oblong, or cylindrical, enclosed in a tegument, associated in families surrounded by a universal tegument, immersed in a more or less firm mucilage. Division in one, two, or three directions alternately. Propagation by quiescent gonidia.

FAMILY I. CHROOCOCCACEÆ.

Thallus mucous or gelatinous, amorphous, enclosing cells and families irregularly disposed.

Genus 77. CHROOCOCCUS. Nägeli. (1849.)

Cells globose or more or less angular, solitary or associated in families, free. Cell-membrane thin, often confluent in a more or less firm jelly; cell-contents verdigris or pallid blue-green. Propagation by division alternately in three directions (Fig. 77).


Cells oblong, twin, or in fours, with a distinct hyaline ellipsoid tegument. Cell-membrane thin; cell-contents
blue-green. Cells 3–6μ diam.; families of 2–4 individuals.

On damp walls and flower-pots.


Cells spherical, or more or less angular, single, 2, 3 or 4 (rarely 8), associated in families; tegument thick, usually lamellose. Cell-membrane thin; cell-contents bright verdigris green, at length brownish. Cells 13–25μ diam.; families of 2–4.

In swampy places and on moist rocks.

Genus 78. Glœocapsa. Kutz. (1843.)

Cells spherical, either single or associated in families, the single cell included in a vesiculiform tegument, dividing into two daughter-cells; the whole surrounded by the tegument of the mother-cell. Cell-membrane thick, equalling in diameter the cavity of the cell, mostly lamellated; cell-contents aëruginous, bluish green, steel-blue, reddish, yellowish, fuscous, etc. Division of the cells in three directions (Fig. 78).

274. Glœocapsa coronina. (Kutz.) Cooke, Algæ, t. 83, f. 3.

Thallus crustaceous, very black, lubricous. Single cells spherical, small; tegument very pale violet, distinctly lamellose. Cell-contents homogeneous, blue-green. Cells 3–4; with envelope, 6–14μ; families 9–75μ diam.

On rocks, and on boggy ground amongst moss.


Thallus crustaceous, mucous, black. Cells spherical, small; tegument very thick, hyaline, 2 or 3 times broader than the central cell. Cell-contents pale verdigris green, rather granulated. Cells 3½–4½μ; with envelope, 14μ; families 10–80μ.

On rocks in mountain regions.
276. **Gloeocapsa livida.** (Carm.) Cooke, Algæ, t. 83, f. 5.

Thallus mucous, rounded lobate, broadly expanded, hyaline, dingy green, or olive brownish. Cells very minute; tegument pale bluish, hyaline. Cell-contents solid, dark blue-green. Cells 3–6μ; with envelope, 6–7μ; families 16–50μ.

On naked ground, or amongst moss and lichens.

277. **Gloeocapsa caldariorum.** (Rabh.) Cooke, Algæ, t. 83, f. 6.


On walls, flower-pots, glass, etc., in conservatories and greenhouses.

278. **Gloeocapsa polydermatica.** (Kutz.) Cooke, Algæ, t. 83, f. 7.

Thallus gelatinous, more or less compact, dirty green, becoming brownish. Cells small, spherical; tegument very thick, lamellose. Cell-contents verdigris green. Cells 3–4½μ; with envelope, 23μ; families 50μ.

On moist rocks.

279. **Gloeocapsa quaternata.** (Kutz.) Cooke, Algæ, t. 83, f. 8.

Thallus mucous, effused, dirty green, then reddish brown. Cells usually spherical, single or 2 to 4 (rarely 6–8) in families; tegument narrow, lamellose, rounded or oblong. Cell-contents verdigris green. Cells 3–4½μ; with envelope, 7–11μ; families 11–22μ.

On rocks or moist ground (Scotland).

280. **Gloeocapsa arenaria.** (Hass.) Cooke, Algæ, t. 84, f. 1.

Thallus mucous, somewhat olive-coloured. Cells large, spherical; tegument thick, almost spherical, lamellose. Cell-contents verdigris green, then brownish. Cells 3½–5μ; with envelope, 6–14μ; families 40μ.

In springs and thermal waters.
281. *Gloeocapsa aeruginosa.* (Carm.) *Cooke, Algae*, t. 84, f. 2.

Thallus crustaceous, glaucous green. Cells small, spher-ical; tegument thick, indistinctly lamellose, externally not rarely angular. Cell-contents verdigris green. Cells 2–3\(\mu\); with envelope, 4\(\frac{1}{2}\)–9\(\mu\); families 16–50\(\mu\).

On limestone and other rocks.

282. *Gloeocapsa magma.* (Breb.) *Cooke, Algae*, t. 84, f. 3.

Thallus grumous, rather crustaceous, purple brown, blackish when dry. Cells spherical; tegument lamellose, intense purple or coppery-brown, external stratum very broad, paler. Cell-contents verdigris green, then brownish. Cells 4\(\frac{1}{2}\)–7\(\mu\); with envelope, 6–12\(\mu\).

On moist rocks.

283. *Gloeocapsa rupicola.* (Kutz.) *Cooke, Algae*, t. 84, f. 4.

Thallus black, then brown, crustaceous, thin. Cells small, spherical; tegument narrow, not lamellose, fuscous, then rusty-brown, for the most part in fours, rarely in twos; outer tegument broad, very pale, enclosing numerous smaller families. Cell-contents pale verdigris green, or rusty brown. Cells 3\(\frac{1}{2}\)–5\(\mu\); families 70\(\mu\).

On rocks amongst moss (Scotland).


Thallus effused, gelatinous, thin, blood red, or thicker, and then becoming blackish brown. Cells spherical; tegu-ment intense blood red, not lamellose, the extreme outer colourless or nearly so, very broad, globose or angular. Cell-contents verdigris green. Cells with envelope 4–9\(\mu\); families to 140\(\mu\).

On rocks.


Thallus gelatinous, dark purple brown. Cells spherical; tegument very thick, opaque, and intense purple, the outer very broad, usually angular, almost colourless, enclosing smaller families of 2, 4, 6, 8. Cell-contents pale
verdigris green. Cells with envelope 10–17μ; small families 22–40μ; large families to 170μ.

Amongst moss and lichens.

286. Glæocapsa Shuttleworthiana. (Kutz.) Cooke, Alge, t. 85, f. 3.

Thallus gelatinous, compact, dark rufous brown. Cells small, spherical; tegument very thick, many times broader than the central cell, globose, intense orange red, the outer pale orange, or colourless. Cell-contents pale verdigris green. Cells with envelope 7½–13μ; families 35μ.

On moist rocks and amongst moss.

287. Glæocapsa rupestris. (Kutz.) Cooke, Alge, t. 84, f. 5.

Thallus dark brown, crustaceous, rather hard. Cells spherical; tegument very thick, lamellose, yellow or golden brown, the outer permanent, yellowish. Cell-contents verdigris green. Cells with envelope 6–9μ; families 15–75μ.

On rocks.

Genus 79. Aphanocapsa. Näg. (1849.)

Cells spherical, with a thick, soft, colourless tegument, confluent in a homogeneous mucous stratum. Cell-division as in Glæocapsa (Fig. 79).


Thallus gelatinous, more or less expanded, dirty green or olive, becoming brownish. Cells pale bluish green, solitary or in pairs; tegument scarcely visible. Cell-contents homogeneous. Cells about 5½μ.

On stones, rocks, etc.

289. Aphanocapsa rivularis. (Carm.) Cooke, Alge, t. 86, f. 2.

Thallus hemispherical, gelatinous, tuberculose, often confluent, æruginous green, becoming brownish when dry. Cells spherical, single or in pairs; tegument very thick, not

On rocks and stones inundated, in mountain streams.

290. Aphanocapsa Grevillei. (Hass.) Cooke, Algæ, t. 86, f. 3.

Thallus gelatinous, globose, densely aggregated, more or less confluent, dirty green, olive to brownish when dry. Cells spherical or elliptic, single or in pairs, in a homogeneous jelly; tegument diffuent. Cell-contents blue-green. Cells 3½–6μ diam.

On damp heaths and moors.


Thallus somewhat hemispherical, depressed, gelatinous, green. Cells spherical or irregular, variable in size. Cells 2½–3μ.

On an old pump, constantly moistened.

Genus 80. MICROCYSTIS. Kutz. (1833.)

Cells spherical, numerous, densely aggregated, enclosed in a very thin globose mother-vesicle, forming solid families, singly, or several, surrounded by a universal tegument. Cell-division in three directions alternately (Fig. 80).

292. Microcystis protogenita. (Bias.) Cooke, Algæ, t. 86, f. 5.


In water long standing, stagnant ditches.

293. Microcystis marginata. (Meneg.) Cooke, Algæ, t. 86, f. 6.


In ditches, free swimming.
Genus 81. CLATHROCYSTIS. Henfrey. (1856.)

Frond gelatinous, at first solid, then saccate, ultimately clathrate, composed of a colourless matrix, in which are imbedded innumerable minute cells, which multiply by division within the frond (Fig. 81).

294. Clathrocytis aeruginosa. (Henf.) Cooke, Algæ, t. 86, f. 7.

Fronds floating in vast strata on fresh-water pools, forming a bright green scum, presenting to the naked eye a finely granular appearance; when dried, appearing like a crust of verdigris. Cells minute. Fronds 30-130μ; cells 2½-3½μ.

On fresh-water lakes.

Genus 82. CÆLOSßÆRIUM. Näg. (1849.)

Thallus globose, small, hollow, composed of small cells, which are associated in families at the periphery, immersed in a mucous stratum. Increase by division of the cells in all directions (Fig. 82).

295. Cælosphærium Kutzingianum. (Näg.) Cooke, Algæ, t. 87, f. 1.

Families spherical. Cells subglobose, geminate, or quaternate, loosely disposed. Cell-contents blue-green, delicately granulose. Cells 2-5μ; families 60μ and more.

In ponds, meres, etc.

Genus 83. GOMPHOSPHÆRIA. Kutz. (1836.)

Cells wedge-shaped, peripherical, 2-4-8 associated in radiating families, nestling in jelly, covered with a tegument, and forming a solid globose free-swimming thallus. Cells dividing alternately in three divisions (Fig. 86).

296. Gomphosphæria aponina. (Kutz.) Cooke, Algæ, t. 87, f. 2.

Thallus blue-green, often becoming pale; tegument colourless, rather thick and somewhat lamellose. Central
cells smaller. Cell-contents verdigris or pale blue-green. Cells 4μ diam. to 10μ long; families 50μ.
In ditches.

Genus 84. **Merismopedia.** Meyen. (1839.)

Cells globose, at the time of division oblong, rather thick; teguments confluent, 4–8–16–32–64–128 associated in tabular families of a single stratum, forming a quadrate, plane, free-swimming thallus (Fig. 87).

297. **Merismopedia violacea.** (Kutz.) Cooke, *Algæ,* t. 87, f. 3.
Thallus mucous, colourless, or nearly so, indefinite. Families small, composed of 4–32 remote very minute cells. Cell-contents homogeneous, violet. Cells 1–1¼μ; families 15μ.
In ponds, ditches, etc., amongst other algæ.

298. **Merismopedia glauca.** (Nag.) Cooke, *Algæ,* t. 87, f. 4.
Thallus more or less limited, glaucous green, margin slightly sinulately crenate. Families composed of 16–48–64 (rarely more) oval or globose cells. Cell-contents pale blue-green. Cells 3–5μ; families 40–50μ.
In stagnant water.

299. **Merismopedia punctata.** (Meyen.) Cooke, *Algæ,* t. 87, f. 5.
Thallus less limited, almost colourless, for the most part composed of 4–64 remote cells. Cell-contents pale blue-green. Cells 3½μ; families 60μ.
In stagnant water.

Family of 8 cells. Cells square in outline, with rounded corners, each divided in four. Length of family 50μ, breadth 25μ; cells 12½μ.
In bog pools.
Genus 85. TETRAPEDIA. Reinsch. (1867.)

Cells compressed, quadrangular or triangular, equilateral, becoming subdivided into quadrate or cuneate segments, or rounded lobes, either by deep incisions, or wide angular sinuses (Fig. 88).

301. Tetrapedia Crux-Michaeli. (Reinsch.) Cooke, Algæ, t. 87, f. 8.

Cells quadrate, lateral margins with two shallow concavities, producing an obtuse-angled central prominence, deeply incised at the angles; incisions diagonal, rectilineal, deep, slightly expanding upwards, dividing the cell into four cuneate segments; in side view lanceolate; ends acute. Cells 8-12 μ diam.

In running water, Ireland.


Cells quadrangular, two opposite margins excavated by a wide triangular sinus, the upper margins of the segments very slightly concave at the middle; in side view oblong, constricted at the middle; ends rounded. Largest cell 7½-10 μ diam.

In moor pools, co. Dublin and Wicklow.

303. Tetrapedia setigera. (Archer.) Cooke, Algæ, t. 87, f. 10.

Cells triangular, 3-lobed, rounded at the ends, and each terminated by a very delicate straight bristle; in side view oblong, somewhat inflated at the middle at each side; ends round, each tipped by the bristle. Cells, without bristles, 6-7½ μ; including bristles, 16-20 μ.

In moor pools, co. Dublin and Wicklow.

Genus 86. SYNECHOCOCCUS. Nüg. (1849.)

Cells oblong, usually single, sometimes 2-4 connected in a series constituting a family. Cell-membrane thin; cell-contents blue-green, now and then yellow or pale orange. Division in one direction only.

Cells broadly elliptic, about one-half longer than broad. Cell-wall very thin.

In shallow pools, Bray's Head, Ireland.

**Genus 87. GLOEOTHECE. Nüg. (1849.)**

Cells cylindrical-oblong, rounded at the ends; division transversal, in one direction. Other characters as in *Gloeocapsa.* Tegument very thick, lamelloose (Fig. 89).


Cells oblong-cylindrical, 2–4 associated in families; involved in a special universal tegument which is globose or oval, 1½ to 3 times as long as broad. Cell-contents verdigris green. Cells 4–5μ; with tegument, 8–12μ; families 25–45μ.

On rocks.

306. *Gloeothee granosa.*  (Rabl.) Cooke, Algæ, t. 88, f. 2.

Thallus compact-gelatinous, blue-green. Cells oblong, twice as long as broad, usually 2–4 associated in families; tegument very broad, many times exceeding the central cell, distinctly lamellose, colourless. Cell-contents pallid blue-green. Cells 14–18μ diam.

On mosses in swamps.

**Genus 88. APHANOTHECE. Nüg. (1849.)**

Differing from *Gloeothee* in all the tegments being usually confluent. Cells oblong or subcylindrical. Cell-contents now and then green, and then with difficulty distinguished from *Palmella* (Fig. 90).

307. *Aphanothee prasina.*  (Br.) Cooke, Algæ, t. 88, f. 3.

Thallus gelatinous, more or less globose, tuberculose, the size of a cherry, bright leek-green, sometimes confluent, and then lobed. Cells oblong or ovoid, 1 to 2 times longer
than broad, after division spherical; tegument none. Cell contents verdigris green. Cells 5–6 × 8–11μ.

In ditches and stagnant ponds.

308. Aphanothece stagnina. (Spr.) Cooke, Algæ, t. 88, f. 4.

Thallus gelatinous, oblong or elliptical, from the size of a pea to that of a cherry, pale verdigris green. Cells oblong-oval, always smaller than in A. prasina, half to once longer than broad; tegument none. Cell-contents pallid verdigris green. Cells 3–5 × 5–8μ.

In stagnant water.

Genus 89. HOMALOCOCCUS. Kutz. (1863.)

Thallus globose, gelatinous. Internal cells irregularly united in a plane, oblong body, immersed in the gelatinous thallus (Fig. 21).

309. Homalococcus Hassallii. (Kutz.) Cooke, Algæ, t. 88, f. 5.

Thallus globose, soft, green, of the size of a pea or a hazel-nut. Cells rounded or somewhat angular. Cells 6–7μ diam.

In stagnant water.

ORDER II. NEMATOGENÆ.

Multicellular. Cells forming a filament, usually included in a tubular sheath. Filaments (Trichomes) either simple or branched.

Tribe 1. NOSTOCHINEÆ.

Trichomes simple or branched. Apex obtuse or acute, naked or enclosed in a sheath. Reproduction by fragments of the trichome (hormogones), which are endowed with motion after separating from the mother-plant.

Sub-tribe I. PSILONEMÆ. Filaments not attenuated into a hair-like extremity.
**Family I. NOSTOCEÆ.**

Trichomes furnished with heterocysts, involved in a very copious gelatin, which is collected into a variously expanded thallus, or rarely with the mucilage quickly dissolved.

**Genus 90. NOSTOC. Vauch. (1803.)**

Thallus gelatinous or membranaceous, definite, globose, or variously expanded. Trichomes flexuously curved, irregularly interlaced, now and then vaginate; joints globose or elliptical. Heterocysts terminal or intercalated. Spores equal to the heterocysts, or a little larger, green, becoming bluish, olivaceous, or yellowish brown (Fig. 92).

**I. Intricata. Aquatic. Fronds soft, gelatinous, often floating.**


Fronds lobed, multipartite, free swimming, as large as a walnut; lobes elongated and anastomosing, æreniginous green, at length becoming brownish. Trichomes flexuous; joints short and close, spherical; sheaths uncoloured, very refractive. Heterocysts slightly oblong. Spores subglobose or oval. Joints $3\frac{1}{2}\mu$; heterocysts $5-6\mu$ diam.; spores (in form *intricatum*), subglobose, $6\frac{1}{2} \times 9\mu$.

In ditches (slightly brackish).


Fronds attached or free swimming, bullate and tuberculate, verdigris green, rarely rufescent, becoming olivaceous by age. Trichomes loosely interwoven; joints equal in diameter, rather distant. Spores subglobose. Joints $3\frac{1}{2}-4\mu$; heterocysts $6\mu$; spores, $7 \times 8\mu$.

In ditches.
INTRODUCTION TO FRESH-WATER ALGÆ.

312. Nostoc carneum. (Ag.) Cooke, Algæ, t. 90, f. 1-3.

Frond indefinitely expanded, bullate and undulate, flesh coloured, rufescent or purplish. Trichomes loosely interwoven; joints equal; sheath none, indistinct, or uncoloured. Spores oval. Joints $3\frac{1}{2}-4\mu$; heterocysts $6\mu$ diam.; spores $6 \times 9\mu$.

On rocks.

II. GELATINOSA. Fronds soft and gelatinous, adherent; joints of trichome cylindrically elongated in the young filaments.

313. Nostoc spongiforme. (Ag.) Cooke, Algæ, t. 90, f. 4.

Frond at first subglobose, then expanded, becoming rather firm, pale aeruginous or olive green; surface tuberculated. Trichomes composed of two sorts of joints, one cylindrical, the other cask-shaped or compressed spherical. Heterocysts globose. Spores smooth, oblong. Joints $4\mu$; heterocysts $7-8\mu$; spores $6-7 \times 10-12\mu$.

In wet or inundated places.

314. Nostoc ellipsosporum. (Desm.) Cooke, Algæ, t. 90, f. 8-11.

Terrestrial. Frond plane, gelatinous, rufous brown. Trichomes densely interwoven, pale aeruginous green; joints cylindrically elongated, loosely connected; sheaths broad, homogeneous. Heterocysts elongated, elliptical. Spores oblong, smooth. Joints $4\mu$; heterocysts $6-7\mu$; spores $6 \times 6-8 \times 19\mu$.

On the ground amongst moss.

III. HUMIFUSA. Terrestrial. Fronds globose, then confluent, forming gelatinous patches adhering by their lower face.


Dark green, foliaceous, tuberculate, opaque. Trichomes diffused, irregularly interwoven, pale aeruginous green; sheaths confluent. Heterocysts spherical, usually intercalated. Spores oval. Joints $3\frac{1}{2}\mu$; heterocysts $5\mu$; spores $6 \times 10\mu$.

On calcareous rocks, and the mosses that cover them.
316. Nostoc humifusum. (Carm.) Cooke, Algæ, t. 91, f. 1-3.

Small, at first globose or subglobose, size of a peppercorn, olive, then brownish, shining opaque when dry. Trichomes olive, slender, vertically folded; sheaths well defined. Heterocysts globose. Spores oval. Joints $2_{2/3} \mu$; heterocysts $3 \mu$; spores $4 \times 6 \mu$.

On mosses and on walls in greenhouses, etc.

IV. COMMUNIA. Terrestrial. Fronds at first globose, then tongue-shaped, plane or irregular.

317. Nostoc commune. (Vauch.) Cooke, Algæ, t. 91, f. 4-7.

Adult frond sub-orbicular, folded, undulating, entire or lobed, often perforated, olive, yellowish brown, or becoming brownish. Trichomes flexuous, loosely interwoven, pale blue-green; joints spherical, compressed, uniform. Heterocysts globose. Joints $4_{1/2}-6$ (usually $5$) $\mu$; heterocysts $7 \mu$.

On wet ground.

V. SPHERICA. Fronds globose or subglobose, limited by a firm and resisting periderm.

318. Nostoc sphæricum. (Vauch.) Cooke, Algæ, t. 91, f. 8-11.

Firm, spherical, about the size of a pea, gregarious, olive or bluish green, or brownish, with a firm brownish or colourless periderm. Trichomes compact, densely interwoven at the periphery; joints cask-shaped, or compressed spherical, close together, uniform. Heterocysts subglobose. Spores oval, with a thick tegument, smooth. Joints $4-5 \mu$; heterocysts $6 \mu$; spores $5 \times 7 \mu$.

In springs and mountain rivulets.


Soft, globose, olive, becoming brownish, often forming an irregular crust. Trichomes much spaced out, of unequal size; joints nearly spherical; sheaths often coloured, contrasting with the generally uncoloured jelly. Spores oval, with a smooth tegument. Joints $5-8 \mu$; heterocysts $7 \mu$.

On rocks, overrunning mosses, etc.
INTRODUCTION TO FRESH-WATER ALGÆ.


Very small, punctiform, æruginous green, or brownish olive. Trichomes large, bluish green, or brownish; joints cylindrical, a little constricted at their junction; sheaths broad, brownish or yellowish brown. Heterocysts globose. Spores globose, with a smooth tegument. Joints 8-9μ; heterocysts 9-10μ.

On rocks among moss.

321. Nostoc eærulæum. (Lyngb.) Cooke, Algæ, t. 92, f. 4-6.

Small, globose or subglobose (½ to 4 lines), fixed or free swimming, usually gregarious, blue or greenish blue. Trichomes dissimilar, unequal; joints of two forms, the one (young) elongated, the other larger, nearly spherical, sometimes filled with opaque granules. Joints 4-7μ; heterocysts 8μ.

On mosses and submerged plants.

322. Nostoc pruniforme. (Ag.) Cooke, Algæ, t. 92, f. 7-9.

The size of a pea to that of a damson, olive or dark æruginous green, when old becoming blackish brown, with a coriaceous periderm, and watery within. Trichomes loosely interwoven; joints subglobose, compressed, closely connected. Heterocysts globose, usually terminal. Joints 4-5μ; heterocysts 6-7μ.

In fresh-water pools, rivulets, etc.

VI. VERRUCOSA. Aquatic. Fronds rounded or discoid, then hollow, with a tough periderm.

323. Nostoc verrucosum. (Vaucl.) Cooke, Algæ, t. 92, f. 10-17.

Subglobose or nodulose, warted, brownish green, tolerably soft, with a firm and tough periderm. Trichomes slender, somewhat compact, spaced out, and a little flexuous at the centre, more compact and distorted at the periphery, where they are often deprived of sheaths; joints subglobose, closely connected. Heterocysts spherical. Joints 3-3½μ; heterocysts 6μ; spores 5-7μ.

In streams, attached to stones.
Genus 91. **Anabaena.** Bory. (1823.)

Trichomes moniliform, without sheaths, composed of subglobose cells, some of which are changed into spores, usually brown. Heterocysts intercalated in the trichomes. Spores originating in cells not adjoining the heterocysts (Fig. 93).

324. **Anabaena flos-aquæ.** (Kutz.) Cooke, Algae, t. 93, f. 1.

Free swimming, membranaceous, blue-green. Trichomes curved, often circinate; joints spherical, or elliptic or quadrate. Heterocysts intercalated, elliptical. Spores globose. Cells $4\frac{1}{2}-6\mu$; heterocysts $12-14\mu$ long; spores $8-10\mu$.

*var. circinalis.* (Kirch.) Cooke, Algae, t. 93, f. 1 c.

Trichomes more circinate, and joints rather larger. Cells $7-10\mu$; spores $12-14\mu$ diam.

In ponds, moor pools, etc.

325. **Anabaena variabilis.** (Kutz.) Cooke, Algae, t. 93, f. 2.

Gelatinous, submembranaceous, deep blue-green. Trichomes slightly curved, verdigris green; joints globose or elliptic, compressed subcylindrical, 1 to $1\frac{1}{2}$ times longer than broad. Heterocysts intercalated, paler. Spores seriate, ellipsoid, tawny, with a rather thick membrane. Cells $3\frac{1}{2}-4\mu$; heterocysts $7\mu$; spores $8 \times 12\mu$.

In ditches.

326. **Anabaena Hassallii.** (Nord. and Wiltr.) Cooke, Algae, t. 93, f. 3.

Trichomes equal, curved, often circinate, interwoven in a thin blue-green stratum; joints globose or compressed. Heterocysts spherical, intercalated without order. Spores oblong cylindrical, single or in pairs, distinctly curved, dark blue-green, $1\frac{1}{2}$ to $2\frac{1}{2}$ times as long as broad. Cells $8\mu$; heterocysts $9-10\mu$; spores $12 \times 25\mu$.

In ditches with *Confervæ*, and floating on lakes.
INTRODUCTION TO FRESH-WATER ALGÆ.

327. Anabaena Ralfsii. (Kutz.) Cooke, Algæ, t. 94, f. 1.

Forming strata of a velvety dark green colour; sometimes verging towards verdigris green. Trichomes moniliform; joints spherical. Heterocysts elliptical. Spores elliptic or cylindrical, 1 or 2 in each series not contiguous to the heterocysts. Cells 4\(\mu\) diam.; heterocysts 5-6 \(\times\) 8\(\mu\); spores 8-10 \(\times\) 22-30\(\mu\).

In bogs and rivulets.

328. Anabaena Smithii. (Thw.) Cooke, Algæ, t. 93, f. 7.

Trichomes straight, with a definite gelatinous sheath; joints subspherical, compressed, about as long as wide. Heterocysts subspherical, half as wide again as the joints; puncta very distinct. Spores cylindrical, unequal; ends rounded and somewhat truncate. Cells 4-6\(\mu\) diam.; heterocysts 8-9 \(\times\) 9-13\(\mu\); spores 9-12 \(\times\) 20-40\(\mu\).

In boggy pools with other algæ.

329. Anabaena oscillarioides. (Bory.) Cooke, Algæ, t. 93, f. 6.

Forming a bluish-green stratum. Trichomes elongated flexuous; joints subquadrate. Heterocysts barrel-shaped or elliptic. Spores oval, catenate, somewhat larger than the cells. Cells 4-5 \(\times\) 4-6\(\mu\); heterocysts 6-8 \(\times\) 7-9\(\mu\); spores 7-8 \(\times\) 8-12\(\mu\).

In brackish ditches.

330. Anabaena Thwaitesii. (Ralfs.) Cooke, Algæ, t. 93, f. 5.

Trichomes moniliform, straight or nearly so; joints quadrate. Heterocysts oblong subquadrate, hardly exceeding the joints in diameter. Spores numerous, cylindrical, with truncate ends, variable in length. Cells 6-7\(\mu\); heterocysts 8 \(\times\) 10\(\mu\); spores 10-12 \(\times\) 25-30\(\mu\).

In fresh-water pools and brackish ditches.

Uncertain Species.

331. Anabaena inæqualis. (Ralfs.) Cooke, Algæ, t. 93, f. 4.

Forming extensive strata of a deep green colour. Trichomes stout, moniliform elongated, joints distinct,
at first quadrate, finally orbicular, with granular contents. Heterocysts globose, broader than the ordinary joints, occurring at short intervals. Spores 3 to 4 times longer than broad, with truncate ends, in chains of 2 to 5.

In boggy pools.

Genus 92. Aphanizomenon. Morren. (1839.)

Thallus membranaceous, free swimming, blue, or becoming olive. Trichomes a little attenuated towards the apex, agglutinated densely in fascicles; joints cylindrical, very closely connected, nearly colourless and delicately granular. Spores cylindrical, rounded at the ends, pale blue, or somewhat olive. Exospore thin, quite smooth (Fig. 96).

332. Aphanizomenon flos-aquæ. (Ralfs.) Cooke, Algæ, t. 94, f. 1.

Floating, forming a pale or dark blue-green stratum. Trichomes very thin, nearly straight, aggregated in membranaceous flakes, distinctly or indistinctly articulated, very pale blue or colourless; joints cylindrical, about as long as broad, slightly granular. Spores more or less cylindrical, 6 to 12 times as long as broad, granular. Cells 3–4μ diam.; spores 5 × 30–40μ.

In ditches, ponds, and meres.

Genus 93. Sphærozyga. (Ag.) Ralfs. (1850.)

Trichomes involved in an amorphous mucilage, rarely vaginate, agglutinated in an indefinite gelatinous stratum; joints spherical, elliptical or oblong, transversely compressed and often quadrangular. Heterocysts intercalated, binary, or solitary. Spores originating in cells placed on each side of the heterocysts (Fig. 95).

333. Sphærozyga Carmichaeli. (Harv.) Cooke, Algæ, t. 94, f. 3.

Stratum thin, of a dark or bluish green colour when recent, but opaque and glaucous when dry. Trichomes moniliform, with tapering extremities; joints distinct,
somewhat quadrate. Heterocysts spherical. Spores oblong. Cells $3\frac{1}{2}-4\frac{1}{2}\mu$; heterocysts $6\mu$ diam.; spores $8-10 \times 18-25\mu$.

On damp soil in salt marshes, in brackish ditches, etc.


Stratum bluish or yellowish green. Trichomes monili-form; joints subspherical. Heterocysts smooth, subquad-rate, rather longer than wide. Spores numerous, elliptical, twice as long as wide, not much exceeding in width the joints, commencing to be formed on either side next to the heterocysts. Cells $4\mu$; heterocysts $5 \times 6\mu$; spores $8 \times 16\mu$.

On dead leaves of *Myriophyllum* in a brackish ditch.

*Species imperfectly known.*


Young trichomes, one or several together in a mucous sheath; joints spherical, compressed. Heterocysts spher-oidal, slightly compressed. Spores usually 2 on each side of the heterocysts, large, twice the width of the joints, oblong, half as long again as wide, becoming brown when mature. Cells $6-7\mu$; spores $12 \times 15\mu$.

Amongst *Cladophora fracta* in a brackish ditch.


Forming thick bluish-green gelatinous masses, from which the filaments issue in long rays. Trichomes elongated, ends attenuated; joints quadrate, then globose, the terminal one longer than broad, and usually conical. Heterocysts spherical, larger than the joints. Spores oblong or cylindrical, 1 or 2 on each side of the hetero-cysts. Cells about $5\mu$; spores $8 \times 20-25\mu$.

In streams, pools, etc.


Trichomes scattered; joints minute, somewhat orbicular. Heterocysts minute, barrel-shaped, much narrower than
the spores. Spores very turgid, often nearly orbicular or broadly elliptical, much larger than the joints or heterocysts. Cells about 3½–4μ; spores about 8 × 12–15μ.

Mixed with other algae.


Forming large gelatinous masses, deep green to pale yellowish green. Trichomes elongated, not constricted; joints longer than broad, separated by transverse dissepiments, often so obscure that they can hardly be detected. Heterocysts at first barrel-shaped, finally elliptic. Spores cylindrical, 4 to 6 times longer than broad, truncate, slightly broader than the ordinary joints. Cells 4μ diam.; spores about 7 × 20–30μ.

In ditches and pools.


Stratum deep bluish green. Trichomes elongated, constricted; joints about equal in length and breadth, but when dividing they lengthen. Heterocysts at first barrel-shaped, then elliptic. Spores cylindrical, 4 to 8 times longer than broad; ends at first truncate, but rounded after separation. Cells about 5μ; spores 8 × 25μ.

In bogs.

**Genus 94. CYLINDROSPERMUM.** (Kutz.) Raf.f. (1850.)

Heterocysts terminal, single. Other characters as in *Sphaerozyga.* Spores originating in cells placed just below the heterocysts (Fig. 94).

340. *Cylindrospermum macrospernum.* (Kutz.) Cooke, Algæ, t. 95, f. 1.

Trichomes curved or nearly straight, pale blue green, more or less interwoven; joints globose or elliptic, often mixed with others somewhat cylindrical, either homogeneous or granular. Heterocysts terminal, elliptical.
Spores oblong or cylindrical, green or yellowish brown, darker when mature, twice as long as broad. Cells 3–4μ; heterocysts rather longer; spores $14 \times 25–30\mu$.

341. Cylindrospermum catenatum. (Ralfs) Cooke, Algæ, t. 95, f. 2.

Stratum bluish green. Trichomes straight, or slightly flexuous, generally parallel, moniliform; joints spherical, minute. Heterocysts oval. Spores 2–8 in each series, at first spherical, then oval, but little broader than the heterocysts. Cells about 3μ; heterocysts a little longer; spores about $6 \times 8\mu$.

In fresh water.

Genus 95. NODULARIA. Mertens. (1822.)

Trichomes vaginate, with very closely compressed disc-shaped joints, collected in a gelatinous or membranaceous stratum. Heterocysts intercalated at regular intervals; joints nearly equal, transversely compressed. Spores fuscous, globose, slightly compressed (Fig. 97).

342. Nodularia litorea. (Thur.) Cooke, Algæ, t. 95, f. 3.

Scarcely gelatinous, forming a deep green fleecy covering. Trichomes of considerable diameter, nearly straight; joints blue green, very short and compressed, giving the filaments the appearance of an Oscillaria. Heterocysts pale reddish. Spores elliptical, at length deep brown. Trichome, without sheath, $12\mu$.

In muddy, brackish ditches.

343. Nodularia Harveyana. (Thur.) Cooke, Algæ, t. 95, f. 4.

Trichomes much curved, composed of cells nearly as long as broad. Heterocysts subquadrate, rather longer than wide, and of the same width as the joints. Spores spherical, almost twice the diameter of the joints. Trichomes $6\frac{1}{2}\mu$ diam.

In brackish ditches.
Family II. Lyngbyæ.

Filaments without heterocysts, not setulose, single, and scattered, or numbers associated in bundles and enclosed in a common sheath. Joints shortly cylindrical, disc-shaped in section.

Genus 96. Spirulina. Link. (1834.)

Trichomés articulated, spirally twisted, motile, nestling in a more or less liquid colourless matrical mucilage (Fig. 98).

344. Spirulina Jenneri. (Kutz.) Cooke, Algæ, t. 96, f. 1.

Trichomes more or less elongated, distinctly articulated, spirals lax, distant; joints equal in length to their diameter, or a little shorter. Cell-contents pale or bright blue green. Trichomes 7–8μ diam.
In stagnant water.


Solitary, or forming little green tufts, sometimes almost radiating. Trichomes more or less elongated, nearly erect, pale blue-green, twisted in lax or dense spirals, endowed with active motion. Trichomes 1½–2μ diam.

var. b. minutissima. (Rabb.) Cooke, Algæ, t. 96, f. 3.

Trichomes abbreviated, more loosely spiral.
In fresh, brackish, or thermal waters.

346. Spirulina tenuissima. (Kutz.) Cooke, Algæ, t. 96, f. 2.

Forming a membranaceous, dark blue-green floating stratum. Trichomes very thin, flexuous, very densely spiral, endowed with active motion; joints very indistinct. Spirals 5μ diam.
In brackish ditches.
Genus 97. Oscillaria. Bose. (1800.)

Trichomes simple, articulate, rigid, straight, or a little curved, rarely circinate, brightly coloured (blue-green, steel-blue, violet, æruginous, etc.), motile, nestling in a matrical mucilage; joints disc-shaped in the front view, without a sheath distinct from the trichome (Fig. 99).

347. Oscillaria tenerrima. (Kutz.) Cooke, Algæ, t. 96, f. 4.

Solitary and scattered, or associated in fascicles. Trichomes straight, indistinctly articulate; joints equal in length to their diameter, or a little longer or shorter; ends somewhat acute, slightly inclined. Cell-contents pale blue-green or olive, homogeneous, or very finely granular. Threads 2–2½μ.

In ditches, amongst decaying vegetable matter.

348. Oscillaria leptotricha. (Kutz.) Cooke, Algæ, t. 96, f. 5.

Solitary, scattered, or collected in a very thin blue-green stratum. Trichomes very slender, slightly curved, indistinctly articulate; joints twice as long as broad, or after division equal, attenuated at the ends. Cell-contents pale blue-green, homogeneous, or finally granular. Threads 3μ diam.

In fresh or brackish ditches.

var. splendida. (Grev.) Cooke, Algæ, t. 96, f. 6.

Trichomes not exceeding 2μ diam.
In tubs of water in a stove.

349. Oscillaria spiralis. (Carm.) Cooke, Algæ, t. 98, f. 7.

Effused in a firm coriaceous glossy black stratum. Trichomes radiating, slender, long, flexuous, regularly twisted in spirals. Threads 3½–4μ diam.

On rocks by the seaside.
350. Oscillaria rubiginosa. (Carm.) Cooke, Algæ, t. 98, f. 6.

Stratum gelatinous, dark purple. Trichomes very thin, straight, indistinctly articulated, laid on a thin, compact, greenish substratum. Threads 4–4.5 μ diam.
Rapid streams, and on stones at the bottom of rivers.

351. Oscillaria subfuscæ. (Vauch.) Cooke, Algæ, t. 96, f. 7

Forming a very thin greenish brown, then blackish stratum, shortly radiating. Trichomes equal, straight, curved at the apex; joints about equal in length to breadth; dissepiments distinctly granulate; apical point fimbriate. Cell-contents pale greenish steel-blue, granular. Threads 4½–6 μ diam.
Attached to wood, rocks, stones, etc., in streams.

352. Oscillaria ærugescens. (Drumm.) Cooke, Algæ, t. 98, f. 5.

Stratum of a fine deep green, highly gelatinous, when dried æruginous blue, and glossy. Trichomes very slender, opaque green, conglomerated in large masses, rarely floating, or broken into fragments and suspended like cloudy flocculi in the water; joints about half their diameter long. Trichomes 5 μ diam.
In lakes and pools.

353. Oscillaria tenuis. (Ag.) Cooke, Algæ, t. 96, f. 8.

Forming a bright green or dark blue-green stratum, radiating. Trichomes straight, rather rigid; joints equal or half as long as broad, sometimes a little constricted and granulated; apex more or less attenuated, obtuse, curved or straight. Cell-contents pale watery blue. Threads 5–6 μ diam.
In ditches, swamps, inundated places.

354. Oscillaria antliaria. (Jurgens.) Cooke, Algæ, t. 97, f. 2.

Expanded in a gelatinous submembranaceous stratum, dark steel-blue. Trichomes rigid, straight, tranquil, or oscillating, curved at the attenuated apex; joints equal, or nearly equal (after division half as long); dissepiments
distinctly granular. Cell-contents pale steel-blue or blue-green, nearly homogeneous. Threads $4\frac{1}{2}-5\frac{1}{2}\mu$ diam.

Around pumps, cisterns, etc.


Stratum 3–4 inches, of a dark bluish-green colour, slightly lubricous, shortly radiating, creeping over mosses. Trichomes variously curved, pale blue-green; joints about equal in length to their diameter. Trichomes 6–7µ diam.

In rapid streams, on Hypnum ruscifolium, etc.

356. Oscillaria subuliformis. (Thw.) Cooke, Algæ, t. 98, f. 3.

Stratum of an intense æruginous green. Trichomes bright green, subuliform, gradually attenuated towards the apices, which are subacute and much curved; joints about three-fourths as long as broad, homogeneous. Trichomes 6–7µ diam.

In brackish ditches. Summer and autumn.

357. Oscillaria limosa. (Ag.) Cooke, Algæ, t. 97, f. 3.

Trichomes rigid, straight, actively oscillating, blue-green, interwoven in a thin mucilaginous radiating green stratum, distinctly articulate; joints nearly equal or a little longer than broad (shorter after division); dissepiments granulated; apex obtuse. Cell-contents pallid. Threads 8–10µ diam.

358. Oscillaria irrigua. (Kutz.) Cooke, Algæ, t. 97, f. 5.

Stratum thin, expanded, compact, dark steel-blue. Trichomes straight, flexile, pallid, then livid steel-blue, a little attenuated at the apex; joints equal in length to their diameter (after division half as long); dissepiments granulated; extreme apex broadly rounded. Threads $7\frac{1}{2}$–10µ.

On wet rocks, walls, or overrunning mosses.


Stratum somewhat membranaceous, often floating, steel-blue, or dark olive, nearly black, with radii of the same
colour. Trichomes straight or slightly flexuous, obtusely rounded at the apex, or attenuated, and sometimes bearded; joints equal in length to their diameter (after division one-half or one-third as long); dissepiments distinctly granulated. Cell-contents pale olive, finely granular. Threads 9–10μ diam.

In ditches and ponds.

360. Oscillaria nigro-viridis. (Thwaites.) Cooke, Algae, t. 98, f. 2.

Stratum thin, of a dark olive-green, almost black, growing upon the mud, and subsequently floating in large masses. Trichomes pale dull green, with obtuse, distinctly curved, scarcely attenuated apices; joints indistinct, about half as long as broad. Cell-contents slightly granulose. Trichomes 12μ diam.

In brackish ditches.

361. Oscillaria chalybea. (Mertens.) Cooke, Algae, t. 98, f. 1.

Floating. Stratum broadly expanded, with long radii, dark blue-green or steel-blue, shining. Trichomes pale steel-blue, slightly flexuous, a little attenuated at the apex; joints 3 or 4 times shorter than their diameter, a little contracted; apiculus slightly curved, obtusely rounded. Cell-contents pale steel-blue. Threads 8–10μ diam.

In still and stagnant water.


Stratum mucous, bright æruginous green, or turning dark green, shining. Trichomes rigid, attenuated at the apex; joints one-fourth in length to their diameter; granules scattered or in transverse series. Cell-contents æruginous. Threads 30–45μ diam.

In fresh, or brackish, water.

363. Oscillaria Frolichii. (Kutz.) Cooke, Algae, t. 97, f. 7.

Stratum dark steel-blue, or at first olive, then dark blue, radiating, opaque, shining. Trichomes nearly equal, straight; joints 2, 3, or 4 times shorter than their dia-
meter, with a double series of granular points at the junction; apiculus broadly rounded, straight, or declined. Cell-contents blue, homogeneous. Threads 15–18μ diam.

In ditches, pools, and boggy places.


Stratum thin, covering decayed vegetable matter at the bottom of a ditch, with a dark-brown coating, becoming somewhat greenish in drying. Trichomes very large, rather brittle, their apices rounded, somewhat oblique, and furnished with numerous motionless cilia. Cell-contents distinctly granulose. Trichomes 18μ with sheath.

In a brackish ditch. November.

*Doubtful Species.*


Stratum pale chestnut-brown, gelatinous, shining. Trichomes of medium size, long, straight, fragile, with visible spaces between the joints.

Pools of fresh water near the sea.


Trichomes straight, rigid, fragile, green. Divisions of the joints distinct, rather remote.

In warm water.


Stratum pale blue-green. Trichomes of medium size, pale yellowish green, with the joints rather distant, nearly equal in length to their diameter.

On the ground.

Genus 98. **Microcoleus.** *Desm.* (1823.)

Trichomes rigid, articulate, crowded together in bundles, enclosed in a common mucous sheath, either closed or open at the apex. Sheath ample, colourless, more or less lamelllose, rarely indistinct (Fig. 100).

Effused broadly in a thin dark-green stratum. Trichomes pale blue-green, slightly curved, in fascicles densely contorted about the apex; joints 2 to 3 times longer than their diameter. Divisions paler, nearly hyaline, a little contracted about the apex. Special sheath narrow, very delicate; universal sheath very thick, lamellose. Trichomes \(2^1_2-3\mu\); fascicles 90–120\(\mu\).

On salt marshes.


Stratun thin, or rather compact, dingy æruginous green. Trichomes slightly flexuous, equal, twisted, in dense fascicles; joints nearly twice as long as their diameter, rather remote from each other, leaving a hyaline space between them; apiculus attenuated. Special sheath delicate; universal sheath narrow, scarcely lamellose. Trichomes \(3^1_3-4\mu\); fascicles 30–35\(\mu\).

On the naked road, by roadsides, etc.


Stratum expanded, blue-green or olive, becoming brownish, membranaceous. Trichomes equal, in filiform fascicles, sometimes much elongated, extruding from the opening of a common sheath in a penicillate manner; joints equal in breadth and length; dissepiments granulated; apiculus acute, straight. Trichomes 5–6\(\mu\); fascicles 75–80\(\mu\) diam.

On moist naked ground.

Genus 99. INACTIS. Kutz. (1843.)

Trichomes vaginate, indistinctly articulate, parallel and fastigiate, now and then dichotomous, very densely aggregated and agglutinated in a pulvinate thallus (Fig. 101).

371. Inactis Cresswelli. (Thur.) Cooke, Algae, t. 100, f. 2.

Forming convex roundish or oval patches, which become confluent for several inches. Filaments hyaline, yellowish
or greenish olive, collected into dense rope-like branching bundles, which are fastigiate. Trichomes exceedingly slender, once or twice divided in a dichotomous manner. Trichomes 2½μ diam.

Spreading over soft sandstone rocks.

372. *Inactis tinctoria*. (Thur.) *Cooke, Algæ*, t. 100, f. 3.

Fasciculate cespitose, dingy brown, becoming olive. Trichomes single, or many associated in one sheath; joints equal in length to their diameter, or a little longer. Sheaths broad, colourless, distinctly lamelllose, even. Trichomes 2μ diam.

On aquatic plants.

**Genus 100. LYNGBYA. Ag. ex Thuret.** (1876.)

Filaments enclosed singly in a sheath, simple, or only exceptionally exhibiting the beginning of ramification where the trichome issues from the side of the sheath, often combined in a membranaceous stratum (Fig. 102).


Trichomes rigid, flexuously curved, blue-green, granular, densely interwoven in dark blue-green tufts; joints 3 to 6 times shorter than their diameter, scarcely constricted. Sheaths pellucid, hyaline, becoming brownish, at first scarcely lamelllose, at length when old becoming distinctly lamelllose. Trichomes 25–30μ diam. without sheath.

In brackish water.


Stratum thin, blue-green, shortly radiating. Trichomes rigid, flexuous, vividly oscillating, equal; joints 4 to 5 times as broad as long, constricted at their junction and hyaline; dissepiments granulated; extreme apiculus straight, broadly rounded, paler. Cell-contents pale blue-green, very delicately granular. Threads 13–15μ diam.

In brackish water, and in rock pools by the shore.
375. **Lyngbya ochraea.** *(Thur.)* Cooke, *Algæ*, t. 102, f. 4.

Forming cloud-like floating fragile masses of an ochrey colour. Trichomes very slender, scattered; joints scarcely visible. Trichomes $2\mu$ diam., including sheath. In boggy pools.

376. **Lyngbya inundata.** *(Kutz.)* Cooke, *Algæ*, t. 102, f. 8.

Deep blue-green, with a whitish grumous membranaceous substratum. Trichomes curved rather rigid, pale blue-green, rarely fasciculate. Sheaths narrow; joints shorter than their diameter; dissepiments naked; extreme apex straight obtuse. Trichomes $4\mu$ diam.

-Margin of ditches, by moist roads, on flower-pots, etc.

377. **Lyngbya vulgaris.** *(Kirch.)* Cooke, *Algæ*, t. 102, f. 5.

Stratum thin, more or less expanded, mucilaginous, dark coloured, opaque or shining, rarely lamellose, and without a substratum being formed. Trichomes straight, rigid, distinctly vaginate; joints equal to their diameter or shorter; dissepiments delicately granulated; apex attenuated, somewhat curved, naked. Trichomes $4\frac{1}{2}-6\frac{1}{2}\mu$ with sheath.

On moist naked ground after rain.

378. **Lyngbya papyrina.** *(Kirch.)* Cooke, *Algæ*, t. 102, f. 7.

Forming a thin papery stratum, sometimes shortly radiating, with a pallid or brownish fibrillose substratum, formed from the interlaced empty sheaths. Trichomes equal; joints nearly equal or a little shorter than their diameter, granulated at their junction; apex obtuse, straight, naked. Trichomes $5-6\mu$ diam.; with sheath, $7\frac{1}{2}-9\mu$.

In streams, torrents, aqueducts, canals, etc.

379. **Lyngbya rupestris.** *(Ag.)* Cooke, *Algæ*, t. 101, f. 2.

Stratum compact, rather velvety, gelatinous, lamellose, very shortly radiating, bright blue-green or dark steel-blue, lower strata discoloured and fibrillose. Trichomes

X
rigid, rather flexuous, a little torulose towards the apex; joints equal in length and breadth, very finely punctate; dissepiments granulated; extreme apex paler, sometimes bearded. Trichomes 7–8μ diam.

On moist rocks where the water is constantly trickling, and in mountain streams.

380. *Lyngbya corium.* (Ag.) Cooke, *Algæ*, t. 102, f. 2.

Stratum toughly membranaceous, compact, brown, steel-blue or greenish, interwoven in a mucilaginous substratum. Trichomes straight or flexuous, rather rigid, olive or brown, then yellowish; joints not more than half as long as broad, transversely punctate, granulated; apex conically attenuated, bearded. Trichomes 7–8μ diam.

On the rocky bottom of alpine rivulets.

381. *Lyngbya turfosa.* (Carm.) Cooke, *Algæ*, t. 102, f. 3.

Forming a thick intensely green stratum, with a tough, slimy, ochre-coloured substratum. Trichomes slender, more or less curved, and mostly hyaline at the point; joints not more than half as long as broad, distinct. Trichomes 8μ diam.

On floating sods in old turf-pits.


Substratum velvety, fibrillose, tawny, becoming yellowish, forming a firm compact stratum, of a violet or steel-blue colour, changing to brownish. Trichomes rigid, straight; joints about half as long as broad, with a double row of points at the commissure; apex rather obtuse, naked. Trichomes 8μ diam. Thinner form, trichomes 6–7μ diam.

On stones in mountain streams.

Genus 101. **Symploca.** Kutz. (1843.)

Trichomes articulate, simple, or exhibiting the beginning of ramification, more or less vaginate, ascending from a prostrate base, agglutinated together in erect or
anastomosing fascicles, or wick-like bundles, more or less procumbent, coalescing, and often involved in gelatin (Fig. 103).

383. Symploca lucifuga. (Harv.) Cooke, Alga, t. 103, f. 2.

Dark æruginous green. Fascicles about 2 lines high, approximate, subuliform; apex at length penicillate. Trichomes single or twin, æruginous; joints equal or a little longer than broad, distinctly granulated. Sheaths broad, pellucid, colourless, quite smooth. Trichomes $\frac{3}{2}-4\mu$ diam.; including sheath, $10\mu$.

On pastures and heaths, on decayed alder trunk.


Steel-blue or olive becoming blackish. Fascicles as much as 1 inch high, densely aggregated, often coalescing, subuliform, straight. Trichomes pale blue-green or steel-blue, densely agglutinate, distinctly articulated; joints equal or a little longer than broad. Cell-contents granular. Sheaths broad, pellucid, homogeneous. Trichomes $8\frac{1}{2}-4\mu$ diam.

Overrunning mosses in shady sub-alpine situation.

Genus 102. PLECTONEMA. Thur. (1875.)

Filaments branched. Ramifications produced by the branching of the trichome outside of the sheath very irregular, and often geminate as in Scytonema (Fig. 105).


Forming floccose tufts, blue-green, now and then turning brownish. Trichomes with pseudo-branches usually in pairs and parallel; joints shorter than their diameter, granular. Sheath narrow, colourless or yellowish, quite smooth. Filaments $21\mu$ with sheath.

In small streams.
308 INTRODUCTION TO FRESH-WATER ALGÆ.


At first attached, soon floating, and forming subglobose woolly tufts, of a dark bluish green, changing to olivaceous. Tufts from $\frac{1}{2}$–1 inch in diameter. Trichomes radiating, with simple (rarely geminate) branches; joints $\frac{1}{2}$ or $\frac{1}{4}$ as long as broad. Filaments 12–15μ diam. with sheath.

In ornamental water.

**Family III. SCYTONEMEÆ.**

Filaments with lateral ramifications in which some of the cells change into heterocysts.

**Genus 103. SCYTONEMA. Ag. (1824.)**

Sheath enclosing a single trichome, which emerges from the side of the sheath. Ramifications usually geminate, the two filaments given off at a right angle. Heterocysts scattered in the trichome (Fig. 106).

387. Scytonema myochrous. (Ag.) Cooke, Algæ, t. 105, f. 1.

Stratum thin, woolly, dark brown. Trichomes very thick, brown, slightly curved, ascending, blue-green within, reddish at the apex (5–6 terminal joints), distinctly articulated. Pseudo-branches flaccidly erect, about half the thickness of the trichomes. Sheath thick, distinctly lamellose, firm, yellow-brown; that of the branches paler. Heterocysts oblong or sub-cylindrical, colourless, about equal to the inner diameter of the trichomes. Cells 10μ diam.; with sheath, 30μ diam.

On moist rocks.

388. Scytonema natans. (Breb.) Cooke, Algæ, t. 105, f. 2.

Floccose tomentose, green, then brown or olive. Trichomes slender, becoming brownish, internally æruginous
green, distinctly articulate; joints nearly equal, granular. Pseudo-branches very slender, more or less distant, very shortly articulated. Sheaths firm, lamellose, yellow or brownish. Branches paler, indistinctly lamellose. Heterocysts interspersed, oblong or ovoid, pellucid. Threads, with sheath, 25μ; without sheath, 7μ.

In stagnant water.

389. **Seytonema cinereum.** (Meneg.) Cooke, Algæ, t. 106, f. 1.

At first pulvinate, cinereous green, then confluent, forming a more or less tomentose pulverulent stratum (becoming pale blue when dry), now and then violet or purplish. Trichomes very fragile, flexuose and curved, loosely interwoven, sparingly branching, indistinctly articulate, aëruginous green; joints shorter than broad. Sheaths thick, golden brown, often encrusted with deposit of lime. Trichomes 8μ, including sheath.

On walls, stones, overrunning moss, etc.

390. **Seytonema interruptum.** (Thw.) Cooke, Algæ, t. 106, f. 2.

Intense blue-green, forming a stratum. Sheath furnished throughout with numerous branched and anastomosing rootlets. Trichomes distinctly annulate, interrupted heterocysts. Branches in pairs arising from the protruded trichome.

In wet heathy places, coating mosses, etc.

**Genus 104. PETALONEMA.** Berk. (1832.)

Trichomes enclosed in a very broad striate membranous sheath, which forms a transparent layer, resembling a hyaline wing (Fig. 104).

391. **Petalonema alatum.** (Berk.) Cooke, Algæ, t. 107, f. 1.

Forming a thin brown stratum. Trichomes small, a few lines only in length, winged, obtuse; each wing thrice the breadth of the filament, white, somewhat transparent, bright yellow next the filament, exhibiting a numerous series of transverse lines or folds. Endochrome
INTRODUCTION TO FRESH-WATER ALGÆ.

of the central thread greenish and septate. Trichomes 10μ; with sheath, from 50–120μ.
On rocks exposed to the trickling of water.

Genus 105. SYMPHYOSIPHON. Kutz. (1843.)

Trichomes as in Scytonema. Filaments agglutinated in erect wick-like bundles (Fig. 107).

392. Symphyosiphon Hoffmanni. (Kutz.) Cooke, Algæ, t. 107, f. 2.

Terrestrial. Tufts small, ascending, dark brown. Trichomes simple, erect, loosely collected in pointed fascicles, internally pale séruginous green, sometimes interrupted; joints delicately granulose, inferior cylindrical, thin, superior thicker and more or less swollen. Sheath firm, broad, attenuated upwards, rarely acute, colourless, or yellowish towards the base. Heterocysts intercalated, globose, hyaline. Trichomes 10μ diam.; with sheath, 12–14μ.

On naked ground, overrunning mosses, etc.

Genus 106. TOLYPOTHRIX. Kutz. (1843.)

Trichomes spuriously branched. Pseudo-branches spreading. Ramifications rarely geminate, oftener solitary, and originating near the heterocysts. One or several heterocysts placed directly above each branchlet (Fig. 108).


Coespitose, dark blue-green. Trichomes and pseudo-branches elongated, flaccid, arising from a prostrate base, internally pale blue-green, interrupted or torulose, distinctly articulate; joints a little shorter than broad. Sheaths colourless, hyaline, rather broad. Heterocysts towards the base, subglobose or oblong, 2 or 3 together, colourless. Trichomes 10μ.

In pools, etc.
394. **Tolypothrix distorta.** (Kutz.) *Cooke, Algæ, t. 108, f. 2.*

Cœspitose floccose, bright blue-green, now and then pale. Trichomes and pseudo-branches loosely interwoven, internally blue-green, apparently continuous, or distinctly articulate; joints equal or a little shorter than their diameter. Sheaths broad, colourless, rarely pale yellow. Heterocysts at the base, or interjected, subglobose or oblong, often 2–3 together. Trichomes 12μ.

In swamps.

395. **Tolypothrix æagropila.** (Kutz.) *Cooke, Algæ, t. 109, f. 1.*

Tufts an inch or more broad, somewhat rounded, bright blue-green or greenish olive. Trichomes and pseudo-branches loosely interwoven, internally pallid blue-green, continuous or distinctly articulate; joints equal or a little longer than their diameter. Sheaths narrow, hyaline, colourless. Heterocysts 2 or 3 (rarely more) in a series, oblong, hyaline. Trichomes 10–12μ.

In standing pools.

*var. e. pygmaea.* (Kutz.) *Cooke, Algæ, t. 109, f. 2.*

Tufts small, blue-green or brownish. Trichomes and pseudo-branches slender, very loosely interwoven; joints a little shorter than broad. Sheaths narrow, colourless or yellowish. Trichomes 7–8μ; with sheath, 10μ.

*var. f. muscicola.* (Kutz.)

Cœspitose, blue-green or brownish. Trichomes and pseudo-branches thicker, elongated, loosely intricate, distinctly or indistinctly articulated; joints a little shorter than broad. Sheaths very delicate. Trichomes 8–11μ.

On mosses, etc.

396. **Tolypothrix coæctilis.** (Kutz.) *Cooke, Algæ, t. 109, f. 3.*

Fasciculate, cœspitose, green, then æruginous. Trichomes and pseudo-branches slender, internally pallid, æruginous, distinctly or indistinctly articulate, granulose; joints half their diameter in length. Sheaths very narrow, thin,
INTRODUCTION TO FRESH-WATER ALGÆ.

hyaline. Heterocysts oblong, twin or ternate, colourless. Trichomes 10μ; with sheath, a little more.
In ponds and lakes.

397. Tolypothrix cirrhosa. (Carm.) Cooke, Algæ, t. 108, f. 3.

Floating, cœspitose, olive or blue-green, becoming brownish. Trichomes nearly simple, rather stout, distinctly articulate, pallid blue-green; joints finely granular, 1/2 or 1/3 as long as broad. Sheaths narrow, indistinctly lamellose, smooth. Heterocysts scattered. Trichomes 12-14μ; with sheath, 20-25μ.
In mountain lakes.

Species of Stigonema and Hapalosiphon now generally included with lichens.

SPECIES FOR INQUIRY.


Gelatinous, amorphous. Sheaths of the trichomes thick, mucilaginous, cohering, slightly branched. Internal trichomes blue-green, slender, simple, septate.
In bogs.


Plants densely cœspitose, erect, branched. Branches free, with obtuse rounded apices, and each with a heterocyst at the base. Endochrome annulated, increasing in diameter towards the apices of the filaments. Fronds 200μ long; trichomes 4μ diam.
On rocks.
Sub-Tribe II. **TRICHOPHOREÆ.** Filaments tapering at the top into a hyaline hair.

**FAMILY IV. CALOTRICHEÆ.**

Filaments free, or agglutinated into a definite thallus, terminating at the apex in a delicate hair-like extremity. Heterocysts scattered, or basal.

**Genus 107. CALOTHRIX. Ag.** (1824.)

Trichomes rather rigid, straight, attached, often fasciculate, growing in small tufts, or forming a turf of indefinite extent (Fig. 109).

400. **Calothrix Orsiniana.** (Thur.) Cooke, *Algæ*, t. 113, f. 1.

Stratum pulvinate, 2 lines in thickness, dark brown, lubricous, opaque. Trichomes elongated, branched, nearly equal, cuspidate at the apex or obtuse, distinctly articulate, here and there moniliform. Sheaths thick, lamellose, golden brown, apical portion dividing in fibrous lamellae. Trichomes, with sheath, 10–12μ; without sheath, 4–6μ.

On rocks and submerged stones.

401. **Calothrix Dillwyni.** (Hass.) Cooke, *Algæ*, t. 113, f. 2.

Flaccid, bluish green or brown. Trichomes usually cohering in pairs. Sheaths inconspicuous, except towards the base; joints about half as long as their diameter. Heterocysts at the base of the branches, ovate or cordate. Trichomes 5–6μ; with sheaths, 8–10μ.

On mosses and moist rocks.

*Species uncertain.*


Filaments red, creeping, branched, contained, with their ramifications, within a tough, more or less permanent sheath, which bursts irregularly. Endochrome annulated, very slender, green. Joints about as broad as long.

On moors.
314 INTRODUCTION TO FRESH-WATER ALGÆ.

Genus 108. RIVULARIA. Roth. (1824.)

Frond hemispherical or bladdery. Filaments agglutinated, radiating. Frond with a well-defined outline. Heterocysts basal. Ramifications produced by transverse division of the trichomes. Trichomes never producing any spores (Fig. 112).


Globose, minute, dark coloured, compact. Threads fastigiate, attenuated upwards to the apex, closely cohering, articulated. Heterocysts basal, globose. Sheaths very narrow, almost inconspicuous. Trichomes 7µ at base, 250µ long.

In lakes, ponds, etc.


Hemispherical, confluent in a hard incrusting blue-green or brownish stratum, internally zoned of a darker green. Trichomes rather thick, pale blue-green, slightly flexuous, articulate, ending in a colourless hyaline point. Sheaths narrow, colourless or brownish at the base. Heterocysts globose. Lower joints of the trichomes equal in length to their diameter. Trichomes 6µ diam.

On rocks and stones in streams.

405. Rivularia dura. (Kutz.) Cooke, Algæ, t. 115, f. 2.

Size of a mustard seed, rather hard, dark bluish green, becoming brownish or blackish. Trichomes æruginous, variable, some thin and inarticulate, others thicker, articulate and torulose, all with distinct sheaths, lengthened into a colourless flexuous thread; lower joints as long as broad, or nearly so; upper ones longer, all granulated. Sheath colourless or yellowish. Heterocysts rounded, oblong. Trichomes 3–9µ diam. at the base.

Attached to aquatic plants, especially Chara.

Frond large, convex, becoming hollow underneath, fleshy, lubricous, brownish olive, often including strong particles. Trichomes $6\mu$ diam. at the base.
On cliffs exposed to the trickling of water.

*Species uncertain.*


Fronds minute, aggregated, roundish, wrinkled, ferruginous, cartilaginous. Trichomes dichotomous. Size not stated.
In streamlets, attached to rocks and stones.


Crust very thin, widely spreading. Filaments attenuated at the base, fastigiately branched above the middle, olive green.
On rocks exposed to the spray of cascades.

Genus 109. *ISACTIS*. Thur. (1875.)

Similar to *Rivularia*, from which it differs in the frond being flattened, and in the filaments being erect and parallel, and not radiating (Fig. 110).


Frond crustaceous, plane, suborbicular or confluent, from 1 inch to 2 feet, dull green, darker in the centre, lubricous, gelatinous. Trichomes erect, parallel. Sheaths hyaline. Trichomes $8\mu$ diam.
Parasitic on *Enteromorpha* and other algae.

Genus 110. *GLOIOTRICHIA*. Ag. (1842.)

Trichomes pseudo-ramose, vaginate. Sheaths broad, often saccate at the base, transversely plicate. Spores originating in the lower part of the trichome (Fig. 111).
316 INTRODUCTION TO FRESH-WATER ALGÆ.


Globose or angular, tuberculose, variable, green, becoming brownish. Trichomes straight, torulose, flexuous and hyaline above; lower joints more or less compressed. Sheath broad, here and there constricted, colourless or yellowish. Spores oblong, cylindrical. Heterocysts subglobose. Trichomes 10–12μ at base; with sheath, 30μ diam.; spores 18μ diam., several times as long.
In ditches, ponds, etc.


Size and form of a pea or a cherry, soft, even, dark olive-green or brownish. Trichomes elongated; the lower part blue-green, distinctly articulated, the upper part setiform, colourless, and indistinctly articulated. Lower joints about equal in length and breadth, here and there somewhat swollen. Heterocysts globose or subglobose. Trichomes 10–12μ diam. at base; spores 10–12μ diam., of variable length.
In ponds, ditches, etc., adhering to aquatic plants.

Class III. RHODOPHYCEÆ (or Florideæ.)

Multicellular, with terminal vegetation. Cell-contents for the most part reddish, rarely otherwise coloured. Reproductive organs of three kinds, very often disposed in different plants, viz. (1) Male organs, or antheridia; (2) Female organs, or cystocarps; and (3) Tetrasporangia.

FAMILY I. PORPHYRACEÆ.

Thallus mucous-membranaceous, formed from a single stratum of cells, chiefly purplish. Vegetation by division of cells. Propagation by tetraspores.
Genus 111. **BANGIA.** Lyngb. (1819.)

Thallus filamentous, simple or branched, for the most part purplish, lubricose, formed from a single series of cells. Cell-membrane thick, colourless, sometimes lamellose. Multiplication by division of the cell-contents (Fig. 113).


Forming lax purple tufts. Threads abbreviated, scarcely exceeding 1 inch long, simple, varying in thickness. Joints nearly equal in length to diameter, or one-third as long, more or less constricted. Filaments 30–60μ diam.; cells 10μ long.

Attached to wood and stones in streams.

**Family II. HILDENBRANDTIACEÆ.**

Thallus crustaceous, formed of many strata of cells, at first smooth, then punctate. Cells very minute, rounded, arranged in vertical series. Conceptacles opening with a broad pore. Tetrasporangia pyriform.

Genus 112. **HILDENBRANDTIA.** Nardo.

Character as in the family (Fig. 118).

413. **Hildenbrandtia rivularis.** Ag.

Crustaceous, rosy red. Cells oblong, rounded. Cells 3½–4μ thick, equal or twice as long.

Incrusting stones, etc., in mountain streams.

**Family III. CHANTRANSIACEÆ.**

Forming dwarf pulvinate tufts, purplish violet or steel-blue. Thallus filamentous. Threads articulate, branched,
straight, naked, fasciculately branched above; joints cylindrical. Propagation by immovable spores formed at the tips of the branchlets. Tetraspores rare.

Genus 113. CHANTRANSIA. Fries. (1825.)

The same characters as given above (Fig. 114).


Tufts bright violet, scarcely exceeding 1 line broad, pulvinately rounded. Threads straight. Branches becoming erect, radiately disposed; joints 3 to 6 times as long as broad, the apical joints rather obtuse. Cells 8—9μ diam.

Parasitic on Lemanea, Cladophora, and aquatic mosses.

415. Chantransia Hermanni. (Roth.) Cooke, Algæ, t. 118, f. 2.

Cæspitose, pale rosy-purple, 3 lines long. Threads and branches whip-like, straight. Branchlets spreading, then ascending; joints 3 to 6 times as long as broad, the final joints cuspidate, or rarely piliferous. Cells 9—20μ diam.

On aquatic plants in streams.

416. Chantransia chalybea. (Lyngb.) Cooke, Algæ, t. 119, f. 3.

Cæspitose, steel-blue, about 1 inch long. Threads radiately disposed, adpressed. Branches straight; joints 3 to 6 times as long as broad. Spores collected in a racemose manner on lateral branchlets. Cells 10—11μ diam.

Rivulets, waterfalls, and on water-wheels.

417. Chantransia pygmaea. (Kutz.) Cooke, Algæ, t. 119, f. 2.

Tufts rounded, about 1 line in diameter, dingy greenish, becoming reddish, violet, or steel-blue when dry. Threads proceeding from a common centre, branched upwards in a somewhat fasciculate manner. Branches erect, parallel, rather adpressed; joints 2 to 3 times as long as broad, apical joints obtuse. Fascicles lateral or terminal. Cells 11—14μ diam.

In streams and springs.

Parasitic, rose-red, much branched. Joints many times longer than broad. Spores solitary or in pairs, lateral and terminal, clavate or obovate. Cells 6μ diam.

On *Batrachospermum moniliforme* and *B. atrum*.

*Species uncertain.*


Coespitose, about 1 inch long, steel-blue. Threads sparingly branched. Branches rather elongated, and, as well as the branchlets, somewhat divergent; joints 2 to 3 times as long as broad. Cells about 9–10μ diam.

On old immersed wood.


Plant minute, hemispherical, inky-green, firm. Filaments much branched; joints twice as long as broad. Branches erecto-patent.

On aquatic plants.

**Family IV. BATRACHOSPERMEÆ.**

Dioecious. Thallus filamentous, articulate, branched, violet or violet-purple or bluish-green, covered with mucus. Primary filament of a single central series of cells, either furnished with densely conglobate tufts of verticillate fascicles of branches, or everywhere densely covered with simple or forked branches. Vegetation terminal.

**Genus 114. BATRACHOSPERMUM. Roth. (1800.)**

Thallus moniliform, composed of a simple series of medullary cells, and a cortical accessory parallel series, clothed with subglobosely clustered fascicles of branches (Fig. 115).
421. *Batrachospermum moniliforme.* (Roth.) Cooke, *Algæ,* t. 120.

From 1 inch to 1 foot in length, clothed with a more or less gelatinous mucus, violet-brownish, reddish brown, purple, or bluish green, profusely branched. Joints of the branches similar, oblong or clavate, outer ones sometimes setigerous. Internodes naked, or furnished with scattered accessory branches. Cellules 20–22 × 10μ.

In streams and ditches.

*var. setigerum.* (Rabh.) Cooke, *Algæ,* p. 288.

The extremities of the moniliform branchlets attenuated into a long setiform thread. Cell 20–24 × 10μ.

*var. pulcherrimum.* (Bory.) Cooke, *Algæ,* t. 121.

About 4 inches long, violet or purple, the gelatinous investment less developed. Branches elongated. Whorls rather distant, globose, with the apices of the branchlets almost confluent. Interstitial spaces nearly naked. Cellules 18 × 13–12μ.

*var. proliferum.* (Kutz.) Cooke, *Algæ,* t. 122.

Stem and primary branches densely set with short accessory branchlets. Cellules 18 × 10μ diam.

*var. confusum.* (Hass.) Cooke, *Algæ,* t. 123.

For the most part bright violet, 2–3–4 inches long, and similarly expanded, densely involved in a gelatinous mucus. Whorls approximate, with numerous interstitial branches irregularly disposed. Cellules 20–22 × 10μ.


This variety differs in the large size and very globose form of the joints of the whorls. The apices are very often setiform. Cellules 25 × 20, or 22 × 18μ.

*var. stagnale.* (Ag.) Cooke, *Algæ,* p. 290.

One or two inches long, blue or steel-blue. Whorls of the stem confluent, of the branches distant.
var. alpestre. (Shuttleworth.) Hass., Algæ, t. 14, f. 2.

Frond black, very mucous, much branched, alternately forming very obtuse angles with the principal filaments. Whorls of the stem spherical, distinct, but approximate. Branches compressed.

var. helmintosum. (Bory) Cooke, Algæ, p. 291


var. bambusinum. (Bory) Cooke, Algæ, p. 291.


422. Batrachospermum vagum. (Roth.) Cooke, Algæ, t. 125.

Vaguely branched, 1–3 inches long, brownish or bluish green. Inferior internodes covered with a dense mass of branchlets; the superior naked, or nearly so. Apical joints of the branchlets attenuated into a long bristle. Cellules 25 × 12μ.

var. keratophytum. (Bory) Ann. Mus., t. 31, f. 2.

Beautiful blue-green, thin, very much branched, dichotomous, with the black setaceous base naked. Branches all equal, slender, thin; apex slightly incrassated. Whorls distinct. Cellules clavate, about 30 × 15μ.

423. Batrachospermum atrum. (Harv.) Cooke, Algæ, t. 126, f. 1.

Violet-coloured when moist, dark brown, almost black when dry, vaguely and much branched, reaching 2 inches. Whorls abbreviated, distant. Interstitial branchlets very short, 1 or 2 celled. Cellules 12μ diam.

In streams and ditches.

var. Dillenii. (Bory) Cooke, Algæ, t. 126, f. 2.

Filaments dark brown, very thin. Lower nodes remote, the interstices beset very densely with prominent cells; upper nodes crowded. Branchlets very short, consisting of 3–4 cellules. Extreme apical nodes confluent. Cellules 12μ diam.
INTRODUCTION TO FRESH-WATER ALGÆ.

Genus 115. THOREA. Bory. (1808.)

Thallus filamentose, attenuated, branched, purple-brown, villose, mucous, with a solid central medullary stratum, surrounded by dichotomously divided branchlets (Fig. 116).

424. Thorea ramosissima. (Bory.) Cooke, Algx, t. 127.

From a hand’s-breadth to 1 to 2 feet, very much branched, about the thickness of a horsehair, dark-green, of a beautiful purple-violet when dry. Ramelli spreading horizontally, long and short alternating, articulate. Joints 1 to 3 times as long as broad, or twice that length. Attached to wood, etc.

Family V. LEMANEACEÆ.

Fluviatile. Thallus developed from a confervoid prothallic filament, setaceous, almost simple, hollow, nodose, having an internal and a cortical layer of cells. Polyspores numerous, collected in branched moniliform series, germinating without fertilization.

Genus 116. LEMANEA. Bory. (1808.)

The same characters as above (Fig. 117).

425. Lemanea fluviatilis. (Ag.) Cooke, Algx, t. 128, f. 1.

Simple, or sparingly branched, 3–4 inches long, straight. Nodules rather remote, with about 3 verticillate papillae. Spores 40 × 25μ.

Attached to stones, wood, etc., in streams.

426. Lemanea torulosa. (Roth.) Cooke, Algx, t. 128, f. 2.

Nearly simple, for the most part bent like a bow, 1–2 inches long. Nodules approximate. Papillae flattened, sometimes confluent or almost obsolete. Spores 40 × 22–30μ.

In streams.
ADDENDA.

The following species have been recently recorded; too late for insertion in their proper places.

**Genus 4 bis. TROCHISCIA.** (Kutz) De Toni, Syll., 693.

Cells globose or subglobose. Membrane thick, warded, or spinulose. *Acanthococcus* Lagerh.

**Trochiscia hirta.** De Toni, Sylloge.

Entered at page 193 as *Pleurococcus vestitus*, Reinsch.

**Trochiscia insignis.** Reinsch, t. xii., f. 22.

Large. Cells solitary, globose. Membrane of the cells thick, lamellose, equal to one-fifth of the diameter of the cell, volvate, plicate at the periphery. 68–84μ diam.

In bogs.

**Trochiscia anglica.** Bennett, Journ. R. M. S. (1890.)


In bogs.

**Genus 5 bis. CAPSULOCOCCUS.** Bennett. (1888.)

Cells green, globose, solitary, or 2–8 in families. Tegument lamellose, firm or rather gelatinous, subglobose or ovoid, cup-shaped at the apex, brown.

Cells large, bright green, usually solitary, globose or sub-ellipsoid, or formed from 2–8 smaller cells. Tegument more or less dingy brown, lamellose, becoming rather hard. Cells 20–25μ diam.

In bogs.


Coenobium composed of 4–8–16–32 cells, irregularly disposed. Cells polygonal suborbicular, broadly rounded at the periphery or obtusely angular, with two stout horns, generally abbreviated into warts, or sometimes absent. Membrane firm, reddish when old. Coenobium 125 × 100μ; cells 20–28μ diam.

In bogs.


Coenobium rounded or cubical, composed of 8–50 cells. Cells sub-hexagonal, produced into 3 short hyaline appendages. Areolae regular, 3–4–5 sided. Coenobium 20–62μ; cells 18μ diam.

In bogs.


Sterile cells equal, or 2–3 times longer than broad. Zygospore formed in one of the conjugating cells. Membrane scrobiculate, dark violet. Cells 24μ diam.; zygospore 33μ diam.

In swamps.


In pools, etc.
309*. **Aphanothece microscopica.** Näg., *Einz. Alg.*, t. 1, H.


In swamps.


Trichomes very long and slender, unbranched, 2 or more enclosed in a common mucilaginous sheath. Sheath 6–10 times as broad as the trichomes, pale yellow, diffused, somewhat lamellose. Trichomes 5 μ diam.

In bog pools.
Glossary.

Achromatic, colourless.
Acicular, needle-shaped.
Acuminate, tapering to a point.
Æruginous, of the colour of verdigris—blue-green.
Agamo-hypnosores, neutrally formed resting-spores.
Agamospores, spore formed neutrally without fecundation.
Agamosporous, bearing spores without fecundation.
Alternate, two organs so placed as not to be opposite to each other.
Amœboid, resembling an Amœba.
Amorphous, without definite form.
Amylaceous, resembling starch.
Anastomose, the opening of one vessel into another, applied to threads or tubes which become confluent, and form an irregular network.
Androgonidia, peculiar zoogonidia produced by female plants from which male plants are developed.
Androsporangium, sporangium enclosing spores of male plants, or androspores.
Androspore, a special kind of zoo-

spores produced in cells, which originate the dwarf males in *Edogonium*.
Antheridia, certain reproductive organs supposed to be analogous to anthers, or fecundative.
Apiculus, ending with a short point.
Arcuate, bent like a bow.
Areola, an angular space with an elevated margin.
Articulate, composed of joints.
Bilobate, having two lobes.
Binate, in pairs.
Botryoid, collected in clusters like a bunch of grapes.
Bullate, blistered or puckered.
Capillary, thread-like, resembling a hair.
Carpospore, spores produced (by conjugation) in a sporocarpium.
Cartilaginous, hard and tough like cartilage.
Cauloid, resembling, or analogous to, a stem.
Chlorophyl, the green colouring matter of leaves, and other green parts of plants.
Chlorophyllose, resembling chlorophyl green.
CILIATE, furnished, or fringed, with hairs.
CILIA, CILLIA, hair or bristle placed marginally.
CIRCINATE, curled round, like the young frond of færus.
CIRCUMSICISSILE, cut round transversely.
CLATHRATE, latticed, or perforated like a window.
CENOBIIUM, a community of a definite number of individuals united in one body.
CESPITOSE, growing in tufts, after the manner of turf strictly, with many stems from one root.
CENOBIIUM, a community of a definite number of individuals united in one body.
CIRCUENTRICALLY, in rings, with a common centre.
CORDATE, heart-shaped.
CORIACEOUS, of a leathery consistence.
CORYMBOSE, resembling the inflorescence called a corymb.
CRENATE, notched or scolloped.
CRUSTACEOUS, hard and brittle, or forming a crust.
CUNEATE, shaped like a wedge.
CUSPIDATE, tapering gradually to a sharp stiff point.
CYTOBLAST, a cell-germ.
CYTOIDERM, cell-membrane.
CYTOPLASMA, cell-contents.
DECUSATE, in pairs, alternately crossing.
DEHISCENCE, splitting into regular parts.
DIAPHANOUS, nearly transparent.
DICHOTOMOUS, forked equally.
DIFFLUENT, readily dissolving.
DISSCIOUS, Dioecious, when the male organs are borne on one plant and the female on another.
DISSEPIMENT, a partition or division.
ENCYSTED, enclosed in a cyst or bladder.
ENDOCHROME, cell-contents, colouring matter of cells.
ENDOPHYTAL, growing within plants.
ENDOSOME, the inward current established between fluids of different densities when separated by a membrane.
ENDOSPORIUM, ENDSPORE, the inner coating of a spore.
EPICYNOUS, seated upon the female organ.
EPHYTAL, growing upon plants.
EPISPORE, the outer integument of a spore.
EPIZOOIC, growing upon animals.
EXOSPORIUM, EXOSPORE, the outer membrane of the coat of a spore.
FASCICLE, a bundle.
FASCICULATE, in bundles from a common point.
FILAMENTOSE, composed of threads, thread-like.
FOLLACEOUS, resembling a leaf.
FURFURACEOUS, mealy, or resembling meal.
GEMINATE, produced in pairs.
GENULFLEXOUS, bent angularly like a knee-joint.
GONIDIA, propagative bodies of small size not produced directly or indirectly by any act of fertilization.
GONOSPORE, a ball-like agglomeration of spores.
GYNANDROSPOROUS, bearing male and female spores.
HAMIATE, hook-shaped, resembling a hook.
HETEROCSYST, intercalated cells of a
special character differing from their neighbours.

**Heterogeneous**, unlike, or dissimilar in kind.

**Hexahedral**, having six sides.

**Homogeneous**, of the same kind, consisting of elements of a like nature.

**Hormogone**, special reproductive bodies, composed of a chain of cells.

**Hyaline**, transparent, resembling glass.

**Hypnosporangium**, **Hypnospora**, sporangium enclosing hypnospires.

**Hypnosporangium**, hypnospora, spores which repose some time before germinating = "resting-spores."

**Hypogynous**, seated beneath the female organ.

**Idio-androspores**, neuter individuals, producing androspores (in *Ellogonium*).

**Intercalated**, interspersed, placed between others.

**Inter cellular**, between the cells.

**Interstitial**, placed between.

**Isolated**, detached, placed by itself.

**Iso spore**, applied to spores which are all of one size, or kind, in the same plant.

**Lacuna**, a depression, cavity, or intercellular space.

**Lamellæ**, thin plates or membranes parallel to each other.

**Lamellose**, formed of layers or plates superimposed.

**Lubricous**, slippery.

**Lunate**, crescent-shaped.

**Macrandrous**, having elongated male plants.

**Macrogonidia**, large gonidia.

**Matrical**, belonging to the matrix.

**Mesophytic**, in the middle of a leaf or frond.

**Mesosporium**, **Mesospore**, the middle membrane of the coat of a spore.

**Metagenesis**, a kind of alternation of generations.

**Microgonidia**, small gonidia.

**Microple**, the aperture in the skin of a seed which was the foramen in the ovule, a little scar.

**Mobile**, movable.

**Moniliform**, necklace-shaped, contracted at regular intervals.

**Monoicous**, **Monoeious**, with male and female organs on the same plant.

**Multicellular**, composed of many cells.

**Multilocular**, containing many cells or cavities.

**Multi-partite**, divided into many parts.

**Nanandrous**, having short or dwarf male plants.

**Nodulose**, knotted, or with swollen joints.

**Nucleus**, the central germ around which a cell is formed, small spherical bodies contained within spores or other cells.

**Obcordate**, inversely heart-shaped.

**Octonate**, eight together.

**Oleaginous**, oily, or resembling oil.

**Oogonium**, a kind of ovarian sac containing spores which, when liberated, are called oospores.

**Oospore**, spores produced in an ovarian sac.
Operculum, the lid or cover of a capsule.
Parenchyma, compressed or hexagonal cellular tissue.
Parenchymatous, resembling the cellular tissue termed "parenchyma."
Parietal, growing by, or to, the wall.
Parthenogenesis, production of fertile seeds without sexual impregnation.
Parenchymatous, resembling the cellular tissue termed "parenchyma."
Parthenogonidia, gonidia produced without fecundation.
Patent, spreading.
Pectinate, pinnatifid, with narrow close segments, like the tooth of a comb.
Pedicellate, having a foot, or stem.
Pentahedral, having five sides.
Pericarpium, covering or tegument of fruit.
Periderm, Peridermic, the enclosing membrane.
Peripheral, the outer portion of a circle.
Piliferous, bearing hairs, hairy.
Plicate, folded, or plaited.
Plumose, feathery, or like a feather.
Polymorphism, Polymorphic, having many forms.
Primordial, original, existing from the beginning.
Prothallus, the false thallus first formed on germination of a spore.
Pseudo-branches, false branches, or resembling branches.
Pseudo - ramose, having false branches.
Pyriform, pear-shaped.
Quadri-radiate, with four radii, or rays.
Quaternate, arranged in fours.
Ramulus, a small or secondary branch.
Reniform, kidney-shaped.
Replicate, folded back.
Resting-spore, a spore which becomes quiescent, or rests for a period, more or less long, before germination.
Rhizoid, resembling, or analogous to, a root.
Rostrate, terminating with a beak.
Saccate, in the form of a bag.
Scalariform, barred or crossed like the steps of a ladder.
Scrobiculate, marked with little pits or depressions.
Scutate, buckler-shaped.
Segmentation, dividing into segments.
Segregate, to separate from others, or set apart.
Semi-, prefix signifying "half."
Septum, a partition or division.
Sigmoid, shaped like the letter S.
Sinus, a depression or notch.
Spermatozoa, Spermatozoids, thread-like bodies possessed of motion, supposed to have fecundative power.
Sporangium, Sporangia, a spore-case, having spores produced within it.
Sporiferous, bearing spores.
Sporocarpium, covering or capsule enclosing spores or carpospores.
Sporoderm, the coating or covering of a spore.
Sporules, minute spore-like bodies.
Stratose, arranged in layers or strata.
Stratum, a layer or extended bed.
<table>
<thead>
<tr>
<th><strong>GLOSSARY.</strong></th>
<th><strong>331</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strié</strong>, parallel lines or shallow grooves.</td>
<td><strong>TRUNCATE</strong>, terminating very abruptly.</td>
</tr>
<tr>
<td><strong>Sub-</strong>, a common prefix indicating “almost” or “nearly.”</td>
<td><strong>TUBERCULATE</strong>, covered with warts or tubercles.</td>
</tr>
<tr>
<td><strong>Subulate</strong>, shaped like an awl.</td>
<td><strong>UNICELLULAR</strong>, literally composed of one cell.</td>
</tr>
<tr>
<td><strong>Tangential</strong>, in the direction of a tangent, touching a straight line on the arc of a circle.</td>
<td><strong>VACUOLE</strong>, drops which are seen in the interior of the protoplasm of cells.</td>
</tr>
<tr>
<td><strong>Tegment</strong>, a covering or membrane.</td>
<td><strong>VAGINA, VAGINATE</strong>, a sheath, sheathing.</td>
</tr>
<tr>
<td><strong>Terete</strong>, cylindrical, tapering like the trunk of a tree.</td>
<td><strong>VERRUCOSE</strong>, covered with warts.</td>
</tr>
<tr>
<td><strong>Tetrahedral</strong>, having four sides.</td>
<td><strong>VERTICILLATE</strong>, arranged in whorls.</td>
</tr>
<tr>
<td><strong>Tetraspores</strong>, certain spores produced in fours.</td>
<td><strong>VESICLE</strong>, a bladder-like cavity.</td>
</tr>
<tr>
<td><strong>Thallus</strong>, an expansion somewhat resembling a leaf.</td>
<td><strong>VIBRATILE</strong>, that moves to and fro, or vibrates.</td>
</tr>
<tr>
<td><strong>Torulose</strong>, almost synonymous with moniliform.</td>
<td><strong>ZOOGONIDIA</strong>, gonidia endowed with active motion.</td>
</tr>
<tr>
<td><strong>Trichogonia</strong>, the female reproductive organs in Batrachosperms.</td>
<td><strong>ZOOSPORANGIUM, ZOOSPORANGE, sporangium</strong> enclosing zoospores.</td>
</tr>
<tr>
<td><strong>Trichome</strong>, the thread or filament of filamentous algae.</td>
<td><strong>ZOOSPORES</strong>, locomotive spores.</td>
</tr>
<tr>
<td><strong>Trichotomous</strong>, dividing in threes.</td>
<td><strong>ZYGOSPORE</strong>, a spore resulting from conjugation.</td>
</tr>
</tbody>
</table>
EXPLANATION OF FIGURES.

1. Eremosphaera viridis.
2. Pleurococcus angulosus.
5. Urocococcus Hookerianus.
6. Palmella mucosa.
7. Porphyridium cruentum.
8. Tetraspora gelatinosa.
11. Palmodictyon viride.
12. Raphidium falcatum.
15. Hydrurus penicillatus.
17. Dactylococcus De Baryanus.
18. Mischococcus confervicola.
20. Protococcus viridis.
22. Hydrodictyon utriculatum.
23. Polyedrium longispinum.
25. Ophiocystium cochleare.
26. Sciadium arbuscula
27. Pediastrum Boryanum.
28. Staurogenia rectangularis.
29. Polyedrium tetrahedricum.
30. Sorastrum spinulosum.
31. Celastrum sphæricum.
32. Selenastrum Bibraianum.
33. Hydriadium heteromorphum.
34. Characiellum ornithocephalum.
35. Codilium gregarium.
36. Volvox globator.
37. Chlamydococcus pluvialis.
38. Chlamydomonas pulvisculus.
40. Gonium pectorale.
41. Pandorina morum.
42. Stephanosphaera pluvialis.
43. Zygnema pectinatum.
44. Zygnema subtile.
45. Spirogyra longata.
46. Sirogonium sticticum.
47. Zygochlamys ericetorum.
48. Mongeotia laevis.
49. Mesocarpus recurvus.
50. Mesocarpus depressus.
51. Staurospermum gracillimum.
52. Staurospermum viride.
53. Gonatonema subtile.
54. Botrydium graulatum.
55. Vaucheria sessilis.
56. Prasiola calophylla.
57. Enteromorpha intestinalis.
58. Monostroma Wittrockii.
59. Sphæroplea annulina.
60. Cylindrocapsa involuta.
61. Microspora fugacissima.
62. Conferva fontinalis.
63. Chaætomorpha sutoria.
64. Rhizoclonium Casparyi.
65. Cladophora flavescens.
66. Pithophora Kewensis.
67. Ædogonium ciliatum.
68. Bulbochæte gracilis.
69. Hormiscia zonata.
70. Ulothrix tenuis.
71. Microthamnion vexator.
72. Chroolepus aureus.
73. Schizogonium murale.
74. Draparnaldia glomerata.
75. Stigeoclonium tenue.
76. Young plants of Hormiscia.
77. Chroococcus turgidus.
78. Gloecapsa rupestris.
79. Aphanocapsa virescens.
80. Microcystis protogenita.
81. Clathrocystis æruginosa.
82. Celosphaerium Kutzingianum.
83. Aphanochæte repens.
84. Chætophora elegans.
85. Coleochæte soluta.
86. Gomphosphæria aponina.
87. Merismopædia glauca.
88. Tetrapedia crux michaei.
89. Gloæotheca granosa.
90. Aphanothece stagnina.
91. Homalococcus Hassallii.
92. Nostoc verrucosum.
93. Anabæna flos-aquæ.
94. Cylindrospermum macrosporum.
95. Sphærozyga Broomei.
96. Aphanizomenon flos-aquæ.
97. Nodularia litorea.
98. Spirulina Jenneri.
100. Microcoleus chthonoplastes.
101. Inactis tinctoria.
102. Lyngbya æstuarii.
103. Symplaoa Ralfsiana.
104. Petalonema alatum.
105. Plectonema Kirchneri.
106. Scyttonema natans.
107. Sympbyosiphon Hoffmanni.
108. Tolypothrix ægagropila.
110. Isactis plana.
111. Gloæotrichia natans.
112. Rivularia dura.
113. Bangia atropurpurea.
114. Chantransia Hermanni.
115. Batrachospermum mouiliforme.
116. Thorea ramosissima.
117. Lemanea torulosa.
118. Hildenbrandtia rivularis.
INDEX TO INTRODUCTION.

Abnormal spore-formation, 155
Actinophrys forms, 152
Active motile cells, 143
Addenda, 323
Algae defined, 5
Alternation in Volvocinea, 129
Alternation of generations, 113
Amoeboid forms, 148
Apparatus for collecting, 19
Arrangement of species, 191
Asexual reproduction, 51
Autonomous species, 36

Batrachosperms, reproduction, 85
Blood rain, 173
"Breaking of the meres," 159
British species, arrangement, 191

Cell-multiplication, 28
Chlamydococcus pluvialis, 120
Chroolepus, reproduction, 61
Classification, 184
Collection of fresh-water algae, 15
Coloured lakes, 164
Compensation for injury, 34
Conjugation, forms of, 46
Connumbium, and copulation, 102
Cultivation of algae, 20
Cycle of Botrydiwm, 114
Cylindrocapsa development, 67

Definition of groups, 4
Dimorphism, 45
Disintegration, 43
Division of cells, 28
Dwarf males in Edogonium, 76

Eudorina, reproduction, 88
Fertilization by conjugation, 92
Generations, alternation of, 113
Genuflexuous conjugation, 99
Germination in Edogonium, 132
Germination of spores, 131
Glossary, 327
Gonidia of lichens, 179
Gory dew, 172

Hansgirg on polymorphism, 48
Heterocysts, and hormogones, 65
Historical review, 6
Hypothesis, the dual, 177

Lateral conjugation, 98
Lichens and fungi, 177
Localities of fresh-water algae, 16
Macro- and microgonidia, 56
Mischococcus, reproduction, 111
Motile spermatozoids, 146
<table>
<thead>
<tr>
<th>Mounting for herbarium, 21</th>
<th>Scalariform conjugation, 98</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mounting for microscope, 22</td>
<td>Sexual filaments in <em>Spirogyra</em>, 93</td>
</tr>
<tr>
<td>Moving spores in <em>Spirogyra</em>, 58</td>
<td>Sexual reproduction, 66</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Nostoc and Collema, 182</th>
<th>Specialism in study, 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notable phenomena, 159</td>
<td><em>Sphaereoplea</em>, reproduction, 69</td>
</tr>
</tbody>
</table>

*Edogonium*, reproduction, 76
Oscillation of filaments, 156

<table>
<thead>
<tr>
<th>Pairing in <em>Hormiscia</em>, 111</th>
<th>Thallogens, 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pairing of zoospores, 105</td>
<td><em>Trichogonia</em>, 86</td>
</tr>
<tr>
<td><em>Pandorina morum</em>, 106</td>
<td><em>Vaucheria</em>, reproduction, 79</td>
</tr>
<tr>
<td>Philosophical classification, 188</td>
<td>Water blossom, 166</td>
</tr>
<tr>
<td>Polymorphism, 36</td>
<td>Water net, <em>Hydrodictyon</em>, 56</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rain of blood, 171</th>
<th>Zoogonidia, or germ-cells, 53</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red snow, 167</td>
<td>Zoospores, pairing of, 105</td>
</tr>
</tbody>
</table>

<p>| Reproduction, forms of, 51 | Resting spores in <em>Sphaereoplea</em>, 158 |</p>
<table>
<thead>
<tr>
<th>Index to Genera</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Anabaena, 291</td>
<td>Chytridaceae, 275</td>
</tr>
<tr>
<td>Aphanizomenon, 293</td>
<td>Cladophora, 215</td>
</tr>
<tr>
<td>Aphanocapsa, 280</td>
<td>Clathrocystis, 282</td>
</tr>
<tr>
<td>Aphanochæte, 275</td>
<td>Codium, 216</td>
</tr>
<tr>
<td>Aphanotheca, 285, 325</td>
<td>Coelastrium, 213, 324</td>
</tr>
<tr>
<td>Apiocyctis, 199</td>
<td>Coelosphaerium, 282</td>
</tr>
<tr>
<td>Bangia, 317</td>
<td>Coleochoæte, 274</td>
</tr>
<tr>
<td>Batrachospermeæ, 319</td>
<td>Confervæ, 241</td>
</tr>
<tr>
<td>Batrachospermum, 319</td>
<td>Confervaceæ, 241</td>
</tr>
<tr>
<td>Botrydiaceæ, 234</td>
<td>Cylindrocapsa, 241</td>
</tr>
<tr>
<td>Botrydina, 197</td>
<td>Cylindrosporum, 293</td>
</tr>
<tr>
<td>Botrydium, 234</td>
<td>Dactylococcus, 200</td>
</tr>
<tr>
<td>Botryococcus, 198</td>
<td>Dasygloia, 312</td>
</tr>
<tr>
<td>Bulbochoæte, 262</td>
<td>Dictyosphaerium, 200</td>
</tr>
<tr>
<td>Calothrix, 313</td>
<td>Dimorphococcus, 203</td>
</tr>
<tr>
<td>Calotrichææ, 313</td>
<td>Draparnaldia, 272</td>
</tr>
<tr>
<td>Capsulococcus, 323</td>
<td>Enteromorpha, 239</td>
</tr>
<tr>
<td>Chætomerpa, 243</td>
<td>Eremosphaera, 192</td>
</tr>
<tr>
<td>Chætophora, 273</td>
<td>Eudorina, 218</td>
</tr>
<tr>
<td>Chætophoraceæ, 270</td>
<td>Gloeocapsa, 277</td>
</tr>
<tr>
<td>Chantransia, 318</td>
<td>Gloeocystis, 193</td>
</tr>
<tr>
<td>Chantransiaceæ, 317</td>
<td>Gloeothææ, 285</td>
</tr>
<tr>
<td>Characium, 215</td>
<td>Gloiotrichia, 315</td>
</tr>
<tr>
<td>Chlamydococcus, 217</td>
<td>Gonatococcus, 233</td>
</tr>
<tr>
<td>Chlamydomonas, 217</td>
<td>Gonium, 219</td>
</tr>
<tr>
<td>Chlorococcus, 204</td>
<td>Hildenbrandtiæ, 317</td>
</tr>
<tr>
<td>Chroococcus, 276</td>
<td></td>
</tr>
<tr>
<td>Index to Genera</td>
<td></td>
</tr>
<tr>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>Homalococcus, 286</td>
<td></td>
</tr>
<tr>
<td>Hormiscia, 265</td>
<td></td>
</tr>
<tr>
<td>Hormospora, 201</td>
<td></td>
</tr>
<tr>
<td>Hydriandra, 216</td>
<td></td>
</tr>
<tr>
<td>Hydrodictyon, 208</td>
<td></td>
</tr>
<tr>
<td>Hydrurus, 202</td>
<td></td>
</tr>
<tr>
<td>Inactis, 303</td>
<td></td>
</tr>
<tr>
<td>Lemanea, 322</td>
<td></td>
</tr>
<tr>
<td>Lemaneaceae, 322</td>
<td></td>
</tr>
<tr>
<td>Lyngbya, 304</td>
<td></td>
</tr>
<tr>
<td>Lyngbyaceae, 297</td>
<td></td>
</tr>
<tr>
<td>Merismopedia, 283</td>
<td></td>
</tr>
<tr>
<td>Mesocarpaceae, 231</td>
<td></td>
</tr>
<tr>
<td>Mesocarpus, 231</td>
<td></td>
</tr>
<tr>
<td>Microcoleus, 302</td>
<td></td>
</tr>
<tr>
<td>Microcystis, 281</td>
<td></td>
</tr>
<tr>
<td>Microspora, 242</td>
<td></td>
</tr>
<tr>
<td>Microthamnion, 270</td>
<td></td>
</tr>
<tr>
<td>Mischococcus, 203</td>
<td></td>
</tr>
<tr>
<td>Monostroma, 210</td>
<td></td>
</tr>
<tr>
<td>Mougeotia, 230</td>
<td></td>
</tr>
<tr>
<td>Nematogenae, 286</td>
<td></td>
</tr>
<tr>
<td>Nephrocytium, 202</td>
<td></td>
</tr>
<tr>
<td>Nodularia, 296</td>
<td></td>
</tr>
<tr>
<td>Nostoc, 287</td>
<td></td>
</tr>
<tr>
<td>Nostochinaceae, 286</td>
<td></td>
</tr>
<tr>
<td>Oedogoniaceae, 247</td>
<td></td>
</tr>
<tr>
<td>Oedogonium, 247</td>
<td></td>
</tr>
<tr>
<td>Oocystis, 203</td>
<td></td>
</tr>
<tr>
<td>Ophiocystis, 208</td>
<td></td>
</tr>
<tr>
<td>Oscillatoria, 298</td>
<td></td>
</tr>
<tr>
<td>Palmella, 196</td>
<td></td>
</tr>
<tr>
<td>Palmellaceae, 192</td>
<td></td>
</tr>
<tr>
<td>Palmodictyon, 197</td>
<td></td>
</tr>
<tr>
<td>Pandorina, 219</td>
<td></td>
</tr>
<tr>
<td>Pediastrum, 209, 324</td>
<td></td>
</tr>
<tr>
<td>Petalonema, 309</td>
<td></td>
</tr>
<tr>
<td>Petronema, 312</td>
<td></td>
</tr>
<tr>
<td>Phycocchromophyceae, 276</td>
<td></td>
</tr>
<tr>
<td>Pithophora, 246</td>
<td></td>
</tr>
<tr>
<td>Plectonema, 307</td>
<td></td>
</tr>
<tr>
<td>Pleurococcus, 192</td>
<td></td>
</tr>
<tr>
<td>Polyedrium, 205</td>
<td></td>
</tr>
<tr>
<td>Porphyraeae, 316</td>
<td></td>
</tr>
<tr>
<td>Porphyridium, 197</td>
<td></td>
</tr>
<tr>
<td>Prasiola, 238</td>
<td></td>
</tr>
<tr>
<td>Protococcaceae, 204</td>
<td></td>
</tr>
<tr>
<td>Protococcus, 204</td>
<td></td>
</tr>
<tr>
<td>Rhaphidium, 199</td>
<td></td>
</tr>
<tr>
<td>Rhizoclonium, 244, 324</td>
<td></td>
</tr>
<tr>
<td>Rhodophyceae, 316</td>
<td></td>
</tr>
<tr>
<td>Rivularia, 314</td>
<td></td>
</tr>
<tr>
<td>Scenedesmus, 206</td>
<td></td>
</tr>
<tr>
<td>Schizochlamys, 196</td>
<td></td>
</tr>
<tr>
<td>Schizogonium, 268</td>
<td></td>
</tr>
<tr>
<td>Schizothrix, 325</td>
<td></td>
</tr>
<tr>
<td>Sciaedium, 209</td>
<td></td>
</tr>
<tr>
<td>Scytonema, 308</td>
<td></td>
</tr>
<tr>
<td>Selenastrum, 214</td>
<td></td>
</tr>
<tr>
<td>Sirogonium, 229</td>
<td></td>
</tr>
<tr>
<td>Sorastera, 214</td>
<td></td>
</tr>
<tr>
<td>Sphaeroplea, 241</td>
<td></td>
</tr>
<tr>
<td>Sphaerozyga, 293</td>
<td></td>
</tr>
<tr>
<td>Spirogyra, 223</td>
<td></td>
</tr>
<tr>
<td>Spirulina, 297</td>
<td></td>
</tr>
<tr>
<td>Staurogenia, 214</td>
<td></td>
</tr>
<tr>
<td>Staurospermum, 232</td>
<td></td>
</tr>
<tr>
<td>Stephanosphaera, 220</td>
<td></td>
</tr>
<tr>
<td>Stigeoclonium, 270</td>
<td></td>
</tr>
<tr>
<td>Synphysiophou, 310</td>
<td></td>
</tr>
<tr>
<td>Symploca, 306</td>
<td></td>
</tr>
<tr>
<td>Synechococcus, 284</td>
<td></td>
</tr>
<tr>
<td>Tetrapedia, 284</td>
<td></td>
</tr>
</tbody>
</table>
INDEX TO GENERA.

Tetraspora, 198
Thorea, 322
Tolypothrix, 310
Trochiscia, 323
Ulotrichaceae, 265
Ulothrix, 267
Ulvaceae, 238
Urococcos, 195

---

Vaucheria, 235
Vaucheriaceae, 235
Volvocaceae, 216
Volvox, 218

Zygnema, 221, 324
Zygnemaceae, 221
Zygodonium, 229
Zygophyceae, 220

THE END.
We st., "Newman, lith"
A LIST OF
KEGAN PAUL, TRENCH, TRÜBNER & CO.'S
(LIMITED)

PUBLICATIONS.
A LIST OF
KEGAN PAUL, TRENCH, TRÜBNER & CO.'S
(LIMITED)
PUBLICATIONS.

CONTENTS.

<table>
<thead>
<tr>
<th>General Literature.</th>
<th>2</th>
<th>Trübner's Oriental Series</th>
<th>68</th>
</tr>
</thead>
<tbody>
<tr>
<td>Theology and Philosophy.</td>
<td>31</td>
<td>Military Works.</td>
<td>72</td>
</tr>
</tbody>
</table>
| English and Foreign Philo-
  sophical Library        | 42| Educational               | 73 |
| Science                 | 44| Poetry                    | 80 |
| International Scientific Series | 48| Novels and Tales          | 84 |
| Oriental, Egyptian, etc. | 52| Books for the Young       | 87 |
|                         |   | Periodicals               | 88 |

GENERAL LITERATURE.

Actors, Eminent. Edited by William Archer. Crown 8vo, 2s. 6d. each.

ADAMS, W. H. Davenport.—The White King; or, Charles the First, and Men and Women, Life and Manners, etc., in the First Half of the Seventeenth Century. 2 vols. Demy 8vo, 21s.

AGASSIZ, Louis.—An Essay on Classification. 8vo, 12s.

ALLIBONE, S. A.—A Critical Dictionary of English Literature and British and American Authors. From the Earliest Accounts to the latter half of the Nineteenth Century. 3 vols. Royal 8vo, £5 8s.


ARMITAGE, Edward, R.A.—Lectures on Painting: Delivered to the Students of the Royal Academy. Crown 8vo, 7s. 6d.

AUBERTIN, J. J.—A Flight to Mexico With 7 full-page Illustrations and a Railway Map of Mexico. Crown 8vo, 7s. 6d.

Six Months in Cape Colony and Natal. With Illustrations and Map. Crown 8vo, 6s.

A Fight with Distances. Illustrations and Maps. Crown 8vo, 7s. 6d.

Australia, The Year-Book of, for 1889. Published under the auspices of the Governments of the Australian Colonies. With Maps. Demy 8vo, 10s. 6d.


Essays on Parliamentary Reform. Crown 8vo, 5s.

Some Articles on the Depreciation of Silver, and Topics connected with it. Demy 8vo, 5s.
**A List of**

**BALL, V.**—The Diamonds, Coal, and Gold of India. Their Mode of Occurrence and Distribution. Fcap. 8vo, 5s.


**BAUGHAN, Rosa.**—The Influence of the Stars. A Treatise on Astrology, Chiromancy, and Physiognomy. Demy 8vo, 5s.

**BEARD, Charles, LL.D.**—Martin Luther and the Reformation in Germany until the Close of the Diet of Worms. Demy 8vo, 16s.

Becket, Thomas, Martyr-Patriot. By R. A. Thompson, M.A. Crown 8vo, 6s.


**BEVAN, Theodore F., F.R.G.S.**—Toil, Travel, and Discovery in British New Guinea. With Maps. Large crown 8vo, 7s. 6d.

**BLACKET, W. S.**—Researches into the Lost Histories of America. Illustrated by numerous Engravings. 8vo, 10s. 6d.


**BLEEK, W. H. J.**—Reynard the Fox in South Africa; or, Hottentot Fables and Tales. From Original Manuscripts. Post 8vo, 3s. 6d.

A Brief Account of Bushman Folk-Lore, and Other Texts. Folio, 2s. 6d.

**BOTTRELL, William.**—Stories and Folk-Lore of West Cornwall. With Illustrations by Joseph Blight. Second and Third Series. 8vo, 6s. each.

**BRADLEY, F. H.**—The Principles of Logic. Demy 8vo, 16s.

BRADSHAW—continued.

A B C Dictionary of the United States, Canada, and Mexico. Showing the most important Towns and Points of Interest. With Maps, Routes, etc. New Edition, Revised. Fcap. 8vo, 2s. 6d.


BRENTANO, Lujo.—On the History and Development of Gilds, and the Origin of Trade-Unions. 8vo, 3s. 6d.


BROWN, Horatio F.—Life on the Lagoons. With 2 Illustrations and Map. Crown 8vo, 6s.

Venetian Studies. Crown 8vo, 7s. 6d.

BROWN, Marie A.—The Icelandic Discoverers of America, or, Honour to whom Honour is due. With 8 Plates. Crown 8vo, 7s. 6d.

BROWNE, Hugh Junior.—The Grand Reality. Being Experiences in Spirit-Life of a Celebrated Dramatist, received through a Trance Medium. Edited by HUGH JUNIOR BROWNE. Large post 8vo, 7s. 6d.

Browning Society's Papers.—Demy 8vo, 1881–84. Part I., 10s. Part II., 10s. Part III., 10s. Part IV., 10s. Part V., 10s. Part VII., 10s. Part VIII., 10s. Part IX., 10s. Part X., 10s.

BROWNING.—Bibliography of Robert Browning from 1833–81. 12s.

Poems of, Illustrations to. Parts I. and II. 4to, 10s. each.


BRYANT, Sophie, D.Sc.—Celtic Ireland. With 3 Maps. Crown 8vo, 5s.


BURTON, Lady.—The Inner Life of Syria, Palestine, and the Holy Land. Post 8vo, 6s.
A List of

**BURY, Richard de.**—Philobiblon. Edited by E. C. Thomas. Crown 8vo, 10s. 6d.

**CAMPBELL, Wm.**—An Account of Missionary Success in the Island of Formosa. Published in London in 1650, and now reprinted with copious Appendices. 2 vols. With 6 Illustrations and Map of Formosa. Crown 8vo, 10s.

The Gospel of St. Matthew in Formosan (Sinkang Dialect). With Corresponding Versions in Dutch and English. Edited from Gravius's Edition of 1661. Fcap. 4to, 10s. 6d.

**CATLIN, George.**—O-Kee-Pa. A Religious Ceremony; and other Customs of the Mandans. With 13 Coloured Illustrations. Small 4to, 14s.

The Lifted and Subsided Rocks of America, with their Influence on the Oceanic, Atmospheric, and Land Currents, and the Distribution of Races. With 2 Maps. Crown 8vo, 6s. 6d.

Shut your Mouth and Save your Life. With 29 Illustrations, Eighth Edition. Crown 8vo, 2s. 6d.

**CHAMBERS, John David.**—The Theological and Philosophical Works of Hermes Trismegistus, Christian Neoplatonist. Translated from the Greek. Demy 8vo, 7s. 6d.

**CHARNOCK, Richard Stephen.**—A Glossary of the Essex Dialect. Fcap., 3s. 6d.

*Nuces Etymologicæ.* Crown 8vo, 10s.

Proenomina; or, The Etymology of the Principal Christian Names of Great Britain and Ireland. Crown 8vo, 6s.

Chaucer Society.—Subscription, two guineas per annum. List of Publications on application.

**CLAPPERTON, Jane Hume.**—Scientific Meliorism and the Evolution of Happiness. Large crown 8vo, 8s. 6d.

**CLARKE, Henry W.**—The History of Tithes, from Abraham to Queen Victoria. Crown 8vo, 5s.

**CLAUSEWITZ, General Carl von.**—On War. Translated by Colonel J. J. Graham. Fcap. 4to, 10s. 6d.


A Special Edition for Schools. 1s.


A Special Edition for Schools. 1s. 6d.
CLODD, Edward, F.R.A.S.—continued.


A Special Edition for Schools. In 2 parts. Each 15. 6d.


COLLETTE, Charles Hastings.—The Life, Times, and Writings of Thomas Cranmer, D.D., the First Reforming Archbishop of Canterbury. Demy 8vo, 7s. 6d.

Pope Joan. An Historical Study. Translated from the Greek, with Preface. 12mo, 2s. 6d.

COLLINS, Mabel.—Through the Gates of Gold. A Fragment of Thought. Small 8vo, 4s. 6d.

CONWAY, Moncure D.—Travels in South Kensington. Illustrated. 8vo, 12s.

COOK, Louisa S.—Geometrical Psychology; or, The Science of Representation. An Abstract of the Theories and Diagrams of B. W. Betts. 16 Plates, coloured and plain. Demy 8vo, 7s. 6d.


COTTON, Louise.—Palmistry and its Practical Uses. 12 Plates. Crown 8vo, 2s. 6d.


CURR, Edward M.—The Australian Race: Its Origin, Languages, Customs, Place of Landing in Australia, and the Routes by which it spread itself over that Continent. In 4 vols. With Map and Illustrations. £2 2s.

CUST, R. N.—The Shrines of Lourdes, Zaragossa, the Holy Stairs at Rome, the Holy House of Loreto and Nazareth, and St. Ann at Jerusalem. With 4 Autotypes. Fcap. 8vo, 2s.

DAVITT, Michael.—Speech before the Special Commission. Crown 8vo, 5s.

DAWSON, Geo.—Biographical Lectures. Edited by GEORGE ST. CLAIR, F.G.S. Third Edition. Large crown 8vo, 7s. 6d.

Shakespeare, and other Lectures. Edited by GEORGE ST. CLAIR, F.G.S. Large crown 8vo, 7s. 6d.

DEAN, Teresa H.—How to be Beautiful. Nature Unmasked. A Book for Every Woman. Fcap. 8vo, 2s. 6d.

DEATH, J.—The Beer of the Bible: one of the hitherto Unknown Leavens of Exodus. With a Visit to an Arab Brewery, and Map of the Routes of the Exodus, etc. Crown 8vo, 6s.

DE JONCOURT, Madame Marie.—Wholesome Cookery. Fifth Edition. Crown 8vo, cloth, 1s. 6d.; paper covers, 1s.

DENMAN, Hon. G.—The Story of the Kings of Rome. In Verse. 16mo, parchment, 1s. 6d.

DONOVAN, J.—Music and Action; or, The Elective Affinity between Rhythm and Pitch. Crown 8vo, 3s. 6d.


Shakspere’s Sonnets. With Introduction and Notes. Large post 8vo, 7s. 6d.


Transcripts and Studies. Large post 8vo, 12s.

DOWSETT, F. C.—Striking Events in Irish History. Crown 8vo, 2s. 6d.

Dreamland and Ghostland. An Original Collection of Tales and Warnings from the Borderland of Substance and Shadow. 3 vols. 6s. per vol., sold separately.

Drummond, Thomas, Under Secretary in Ireland, 1835-40. Life and Letters. By R. BARRY O’BRIEN. Demy 8vo, 14s.

DU PREL, Carl.—The Philosophy of Mysticism. Translated from the German by C. C. MASSEY. 2 vols. Demy 8vo, cloth, 25s.

Early English Text Society.—Subscription, one guinea per annum. Extra Series. Subscriptions—Small paper, one guinea per annum. List of Publications on application.


Libraries and Founders of Libraries. 8vo, 18s. Large paper Edition. Imperial 8vo, £1 10s.

Free Town Libraries, their Formation, Management, and History in Britain, France, Germany, and America. Together with Brief Notices of Book Collectors, and of the respective Places of Deposit of their Surviving Collections. 8vo, 21s.

Eighteenth Century Essays. Selected and Edited by Austin Dobson. Cheap Edition. Cloth, 1s. 6d.

Ellis, William (Founder of the Birkbeck Schools). Life, with Account of his Writings. By E. Kell Blyth. Demy 8vo, 14s.


Emerson (Ralph Waldo), Talks with. By Charles J. Woodbury. Crown 8vo, 5s.

English Dialect Society.—Subscription, 10s. 6d. per annum. List of Publications on application.


Five o'clock Tea. Containing Receipts for Cakes, Savoury Sandwiches, etc. Eighth Thousand. Fcap. 8vo, cloth, 1s. 6d.; paper covers, 1s.


FOX, Charles.—The Pilgrims. An Allegory of the Soul's Progress from the Earthly to the Heavenly State. Crown 8vo, 5s.

FOX, J. A.—A Key to the Irish Question. Crown 8vo, 7s. 6d.

FRANKLYN, Henry Bowles.—The Great Battles of 1870, and Blockade of Metz. With Large Map, Sketch Map, and Frontispiece. 8vo, 15s.

FREEBOROUGH, E., and RANKEN, C. E.—Chess Openings, Ancient and Modern. Revised and Corrected up to the Present Time from the best Authorities. Large post 8vo, 7s. 6d.; interleaved, 9s.

FREEMAN, E. A.—Lectures to American Audiences. I. The English People in its Three Homes. II. Practical Bearings of General European History. Post 8vo, 8s. 6d.
A List of

FRITH, J.—Life of Giordano Bruno, the Nolan. Revised by Prof. MORIZ CARRIERE. With Portrait. Post 8vo, 14s.

Froebel's Ethical Teaching. Two Essays by M. J. LYSCHINSKA and THERESE G. MONTEFIORE. Fcap., 2s. 6d.

From World to Cloister; or, My Novitiate. By BERNARD. Crown 8vo, 5s.


GASTER, M.—Greeko-Slavonic Literature and its Relation to the Folk-Lore of Europe during the Middle Ages. Large post 8vo, 7s. 6d.


GIBB, E. J. W.—The History of the Forty Vezirs; or, The Story of the Forty Morns and Eves. Translated from the Turkish. Crown 8vo, 10s. 6d.

GILBERT, Mrs.—Autobiography, and other Memorials. Edited by JOSIAH GILBERT. Fifth Edition. Crown 8vo, 7s. 6d.

Glossary of Terms and Phrases. Edited by the Rev. H. PERCY SMITH and others. Second and Cheaper Edition. Medium 8vo, 3s. 6d.

Goethe's Faust. Translated from the German by JOHN ANSTER, LL.D. With an Introduction by BURDETT MASON. Illustrated by FRANK M. GREGORY. Folio, £3 3s.

GORDON, Major-General C. G.—His Journals at Kartoum. Printed from the original MS. With Introduction and Notes by A. EG MONT HAKE. Portrait, 2 Maps, and 30 Illustrations. Two vols., demy 8vo, 21s. Also a Cheap Edition in 1 vol., 6s.

Gordon's (General) Last Journal. A Facsimile of the last Journal received in England from GENERAL GORDON. Reproduced by Photo-lithography. Imperial 4to, £3 3s.
GORDON, Major-General C. G.—continued.


GOULD, Rev. S. Baring, M.A.—Germany, Present and Past. Large crown 8vo, 7s. 6d.

GOWER, Lord Ronald.—My Reminiscences. Miniature Edition, printed on hand-made paper, limp parchment antique, 10s. 6d.


Last Days of Mary Antoinette. An Historical Sketch. With Portrait and Facsimiles. Fcap. 4to, 10s. 6d.

Notes of a Tour from Brindisi to Yokohama, 1883-1884. Fcap. 8vo, 2s. 6d.


The Social Problem, in its Economic, Moral, and Political Aspects. Demy 8vo, 14s.

GUBERNATIS, Angelo de.—Zoological Mythology; or, The Legends of Animals. 2 vols. 8vo, £1 5s.

GURNEY, Rev. Alfred.—Wagner's Parsifal. A Study. Fcap. 8vo, 15. 6d.


HAGGARD, H. Rider.—Cetywayo and his White Neighbours; or, Remarks on Recent Events in Zululand, Natal, and the Transvaal. Third Edition. Crown 8vo, 6s.

HALDEMAN, S. S.—Pennsylvania Dutch: A Dialect of South Germany with an Infusion of English. 8vo, 3s. 6d.


Harris, Emily Marion.—The Narrative of the Holy Bible. Crown 8vo, 5s.

Hartmann, Franz.—Magic, White and Black; or, The Science of Finite and Infinite Life. Crown 8vo, 7s. 6d.

The Life of Paracelsus, and the Substance of his Teachings. Post 8vo, 10s. 6d.

Life and Doctrines of Jacob Behmen. Post 8vo, 10s. 6d.

Hawthorne, Nathaniel.—Works. Complete in Twelve Volumes. Large post 8vo, 7s. 6d. each volume.

Hecker, J. F. C.—The Epidemics of the Middle Ages. Translated by G. B. Babington, M.D., F.R.S. Third Edition. 8vo, 9s. 6d.

Hendrik, Hans.—Memoirs of Hans Hendrik, the Arctic Traveller; serving under Kane, Hayes, Hall, and Nares, 1853-76. Translated from the Eskimo Language by Dr. Henry Rink. Crown 8vo, 3s. 6d.


Herzen, Alexander.—Du Développement des Idées Révolutionnaires en Russie. 12mo, 2s. 6d.

A separate list of A. Herzen’s works in Russian may be had on application.

Hill, Alfred.—The History of the Reform Movement in the Dental Profession in Great Britain during the last twenty years. Crown 8vo, 10s. 6d.

Hillebrand, Karl.—France and the French in the Second Half of the Nineteenth Century. Translated from the Third German Edition. Post 8vo, 10s. 6d.


The Mystery of Pain. New Edition. Fcap. 8vo, 1s.

Hodgson, J. E.—Academy Lectures. Crown 8vo, 7s. 6d.
Holbein Society.—Subscription, one guinea per annum. List of Publications on application.


HOME, Mme. Dunglas.—D. D. Home: His Life and Mission. With Portrait. Demy 8vo, 12s. 6d.

Gift of D. D. Home. Demy 8vo, 10s.


HOOLE, Henry.—The Science and Art of Training. A Handbook for Athletes. Demy 8vo, 3s. 6d.

HOOPER, Mary.—Little Dinners: How to Serve them with Elegance and Economy. Twenty-first Edition. Crown 8vo, 2s. 6d.

Cookery for Invalids, Persons of Delicate Digestion, and Children. Fifth Edition. Crown 8vo, 2s. 6d.


HOPKINS, Ellice.—Work amongst Working Men. Sixth Edition. Crown 8vo, 3s. 6d.

HORNADAY, W. T.—Two Years in a Jungle. With Illustrations. Demy 8vo, 21s.

HOWELLS, W. D.—A Little Girl among the Old Masters. With Introduction and Comment. 54 Plates. Oblong crown 8vo, 10s.

HUMBOLDT, Baron Wilhelm Von.—The Sphere and Duties of Government. Translated from the German by Joseph Coulthard, Jun. Post 8vo, 5s.

HYNDMAN, H. M.—The Historical Basis of Socialism in England. Large crown 8vo, 8s. 6d.


INGLEBY, the late Clement M.—Essays. Edited by his Son. Crown 8vo, 7s. 6d.
Irresponsibility and its Recognition. By a Graduate of Oxford. Crown 8vo, 3s. 6d.

JAGIELSKI, V.—Modern Massage Treatment in Combination with the Electric Bath. 8vo, 1s. 6d.


JENKINS, Jabez.—Vest-Pocket Lexicon. An English Dictionary of all except familiar Words, including the principal Scientific and Technical Terms, and Foreign Moneys, Weights, and Measures. 64mo, 1s.

JENKINS, Rev. Canon R. C.—Heraldry: English and Foreign. With a Dictionary of Heraldic Terms and 156 Illustrations. Small crown 8vo, 3s. 6d.

Jesus the Carpenter of Nazareth. By a Layman. Crown 8vo, 7s. 6d.


The History of a Slave. With 47 Illustrations. Square 8vo, 6s.


KARDEC, Allen.—The Spirit's Book. The Principles of Spiritist Doctrine on the Immortality of the Soul, etc. Transmitted through various mediums. Translated by ANNA BLACKWELL. Crown 8vo, 7s. 6d.

The Medium's Book; or, Guide for Mediums and for Evocations. Translated by ANNA BLACKWELL. Crown 8vo, 7s. 6d.

Heaven and Hell; or, The Divine Justice Vindicated in the Plurality of Existences. Translated by ANNA BLACKWELL. Crown 8vo, 7s. 6d.

Utopias; or, Schemes of Social Improvement, from Sir Thomas More to Karl Marx. Crown 8vo, 5s.

Christian Socialism. Crown 8vo, 4s. 6d.

KERRISON, Lady Caroline.—A Commonplace Book of the Fifteenth Century. Containing a Religious Play and Poetry, Legal Forms, and Local Accounts. From the Original MS. at Brome Hall, Suffolk. Edited by LUCY TOULMIN SMITH. With 2 Facsimiles. Demy 8vo, 7s. 6d.


The Spiritual Hermeneutics of Astrology and Holy Writ. Illustrated. 4to, parchment, 10s. 6d.

KINGSFORD, Anna, and MAITLAND, Edward.—The Virgin of the World of Hermes Mercurius Trismegistus. Rendered into English. 4to, parchment, 10s. 6d.

The Perfect Way; or, The Finding of Christ. Third Edition, Revised. Square 16mo, 7s. 6d.

KINGSFORD, William.—History of Canada. 3 vols. 8vo, £2 5s.


LAMB, Charles.—Beauty and the Beast; or, A Rough Outside with a Gentle Heart. A Poem. Fcap. 8vo, vellum, 10s. 6d.

LANG, Andrew.—Lost Leaders. Crown 8vo, 5s.

Lathe (The) and its Uses; or, Instruction in the Art of Turning Wood and Metal. Sixth Edition. Illustrated. 8vo, 10s. 6d.

LEE, Frederick Geo.—A Manual of Politics. In three Chapters. With Footnotes and Appendices. Small crown 8vo, 2s. 6d.

LEFEVRE, Right Hon. G. Shaw.—Peel and O'Connell. Demy 8vo, 10s. 6d.


Irish Members and English Gaolers. Crown 8vo, limp cloth, 1s. 6d.; paper covers, 1s.

Combination and Coercion in Ireland. A Sequel to "Incidents of Coercion." Crown 8vo, cloth, 1s. 6d.; paper covers, 1s.
A List of


Gaudeamus. Humorous Poems translated from the German of JOSEPH VICTOR SCHEFFEL and others. 16mo, 3s. 6d.


Fu-Sang; or, The Discovery of America by Chinese Buddhist Priests in the Fifth Century. Crown 8vo, 7s. 6d.


The Gypsies. Crown 8vo, 10s. 6d.

Light on the Path. For the Personal Use of those who are Ignorant of the Eastern Wisdom. Written down by M. C. Fcap. 8vo, 1s. 6d.

LOCHER, Carl.—An Explanation of Organ Stops, with Hints for Effective Combinations. Demy 8vo, 5s.

LONGFELLOW, H. Wadsworth.—Life. By his Brother, SAMUEL LONGFELLOW. With Portraits and Illustrations. 3 vols. Demy 8vo, 42s.

LONSDALE, Margaret.—Sister Dora: a Biography. With Portrait. Thirtieth Edition. Small crown 8vo, 2s. 6d.

George Eliot: Thoughts upon her Life, her Books, and Herself. Second Edition. Small crown 8vo, 1s. 6d.

Lotos Series (The). Pot 8vo, bound in two styles: (1) cloth, gilt back and edges; (2) half-parchment, cloth sides, gilt top, uncut, 3s. 6d. each.

The Original Travels and Surprising Adventures of Baron Munchausen. Illustrated by ALFRED CROWQUILL.


Lotos Series (The)—continued.

The Marvellous and Rare Conceits of Master Tyll Owlglass. Newly Collected, Chronicled, and set forth in an English Tongue. By KENNETH H. R. MACKENZIE. Adorned with many most Diverting and Cunning Devices by ALFRED CROWQUILL.

A Lover's Litanies, and other Poems. By ERIC MACKAY. With Portrait of the Author.

The Large Paper Edition of these Volumes will be limited to 101 numbered copies for sale in England, price 12s. 6d. each, net.


LOWELL, James Russell.—The Biglow Papers. Edited by THOMAS HUGHES, Q.C. First and Second Series in 1 vol. Fcap., 2s. 6d.

LOWESLEY, Major B.—A Glossary of Berkshire Words and Phrases. Crown 8vo, half-calf, gilt edges, interleaved, 12s. 6d.


LUDEWIG, Hermann E.—The Literature of American Aborigna Languages. Edited by NICOLAS TRÜBNER. 8vo, 10s. 6d.

LUKIN, J.—Amongst Machines. A Description of Various Mechanical Appliances used in the Manufacture of Wood, Metal, etc. A Book for Boys. Second Edition. 64 Engravings. Crown 8vo, 3s. 6d.

The Young Mechanic. Containing Directions for the Use of all Kinds of Tools, and for the Construction of Steam-Engines, etc. A Book for Boys. Second Edition. With 70 Engravings. Crown 8vo, 3s. 6d.

The Boy Engineers: What they Did, and How they Did it. A Book for Boys. 30 Engravings. Imperial 16mo, 3s. 6d.

LUMLEY, E.—The Art of Judging the Character of Individuals from their Handwriting and Style. With 35 Plates. Square 16mo, 5s.


MACDONALD, W. A.—Humanitism: The Scientific Solution of the Social Problem. Large post 8vo, 7s. 6d.
A List of

MACHIAVELLI, Niccolò.
Discourses on the First Decade of Titus Livius. Translated from the Italian by Ninian Hill Thomson, M.A. Large crown 8vo, 12s.
The Prince. Translated from the Italian by N. H. T. Small crown 8vo, printed on hand-made paper, bevelled boards, 6s.
MAIDEN, J. H.—The Useful Native Plants of Australia (including Tasmania). Demy 8vo, 12s. 6d.
Maintenon, Madame de. By Emily Bowles. With Portrait. Large crown 8vo, 7s. 6d.
MARCHANT, W. T.—In Praise of Ale. Songs, Ballads, Epigrams, and Anecdotes. Crown 8vo, 10s. 6d.
MARTIN, G. A.—The Family Horse: Its Stabling, Care, and Feeding. Crown 8vo, 3s. 6d.
The Kabbalah Unveiled. Containing the Three Books of the Zohar. Translated into English. With Plates. Post 8vo, 10s. 6d.
The Tarot: its Occult Signification, Use in Fortune-Telling, and Method of Play. 32mo, 1s. 6d.; with pack of 78 Tarot Cards, 5s.
MAUDSLEY, H., M.D.—Body and Will. Being an Essay concerning Will, in its Metaphysical, Physiological, and Pathological Aspects. 8vo, 12s.
Mendelssohn's Letters to Ignaz and Charlotte Moscheles. Translated by Felix Moscheles. Numerous Illustrations and Facsimiles. 8vo, 12s.

METCALFE, Frederick.—The Englishman and the Scandinavian. Post 8vo, 18s.

MINTON, Rev. Francis.—Capital and Wages. 8vo, 1s.

The Welfare of the Millions. Crown 8vo, limp cloth, 1s. 6d.; paper covers, 1s.


MITCHELL, Lucy M.—A History of Ancient Sculpture. With numerous Illustrations, including 6 Plates in Phototype. Super-royal 8vo, 42s.


MORFIT, Campbell.—A Practical Treatise on the Manufacture of Soaps. With Illustrations. Demy 8vo, £2 12s. 6d.

A Practical Treatise on Pure Fertilizers, and the Chemical Conversion of Rock Guanos, etc., into various valuable Products, With 28 Plates. 8vo, £4 4s.


MORRIS, Gouverneur, U.S. Minister to France.—Diary and Letters. 2 vols. Demy 8vo, 30s.

MOSENTHAL, J. de, and HARTING, James E.—Ostriches and Ostrich Farming. Second Edition. With 8 full-page Illustrations and 20 Woodcuts. Royal 8vo, 10s. 6d.


A List of

Natural History. "Riverside" Edition. Edited by J. S. Kingsley. 6 vols. 2200 Illustrations. 4to, £6 6s.

NEVILL, J. H. N.—The Biology of Daily Life. Post 8vo, 3s. 6d.


** A Portrait of Cardinal Newman, mounted for framing, can be had, 2s. 6d.

NEWMAN, Francis William.—Essays on Diet. Small crown 8vo, cloth limp, 2s.


Reminiscences of Two Exiles and Two Wars. Crown 8vo, 3s. 6d.

Phases of Faith; or, Passages from the History of my Creed. Crown 8vo, 3s. 6d.

The Soul: Her Sorrows and her Aspirations. Tenth Edition. Post 8vo, 3s. 6d.

Hebrew Theism. Royal 8vo, 4s. 6d.

Anglo-Saxon Abolition of Negro Slavery. Demy 8vo, 5s.

New South Wales, Journal and Proceedings of the Royal Society of. Published annually. Price 10s. 6d.


New Zealand Institute Publications:

I. Transactions and Proceedings of the New Zealand Institute. Vols. I. to XX., 1868 to 1887. Demy 8vo, stitched, £1 1s. each.

II. An Index to the Transactions and Proceedings of the New Zealand Institute. Edited by JAMES HECTOR, M.D., F.R.S. Vols. I. to VIII. Demy 8vo, 2s. 6d.


O'BRIEN, R. Barry.—Irish Wrongs and English Remedies, with other Essays. Crown 8vo, 5s.
O'BRIEN, R. Barry.—continued.
The Home Ruler's Manual. Crown 8vo, cloth, 1s. 6d.; paper covers, 1s.

OLCOTT, Henry S.—Theosophy, Religion, and Occult Science.
With Glossary of Eastern Words. Crown 8vo, 7s. 6d.

Posthumous Humanity. A Study of Phantoms. By ADOLPHE D'ASSIER. Translated and Annotated by HENRY S. OLCOTT. Crown 8vo, 7s. 6d.


OWEN, Robert Dale.—Footfalls on the Boundary of Another World. With Narrative Illustrations. Post 8vo, 7s. 6d.

The Debatable Land between this World and the Next. With Illustrative Narrations. Second Edition. Crown 8vo, 7s. 6d.

Threading my Way. Twenty-Seven Years of Autobiography. Crown 8vo, 7s. 6d.


Parchment Library. Choicely Printed on hand-made paper, limp parchment antique or cloth, 6s.; vellum, 7s. 6d. each volume.

Selected Poems of Matthew Prior. With an Introduction and Notes by AUSTIN DOBSON.

Sartor Resartus. By THOMAS CARLYLE.


Chaucer's Canterbury Tales. Edited by A. W. POLLARD, 2 vols.

Letters and Journals of Jonathan Swift. Selected and edited, with a Commentary and Notes, by STANLEY LANE-POOLE.

De Quincey's Confessions of an English Opium Eater. Reprinted from the First Edition. Edited by RICHARD GARNETT.


Selections from the Prose Writings of Jonathan Swift. With a Preface and Notes by STANLEY LANE-POOLE and Portrait.

English Sacred Lyrics.

Sir Joshua Reynolds's Discourses. Edited by EDMUND GOSSE.
A List of

Parchment Library—continued.

Selections from Milton’s Prose Writings. Edited by ERNEST MYERS.

The Book of Psalms. Translated by the Rev. Canon T. K. CHEYNE, M.A., D.D.

The Vicar of Wakefield. With Preface and Notes by AUSTIN DOBSON.

English Comic Dramatists. Edited by OSWALD CRAWFURD.

English Lyrics.

The Sonnets of John Milton. Edited by MARK PATTISON.

French Lyrics. Selected and Annotated by GEORGE SAINTS-BURY. With a Miniature Frontispiece designed and etched by H. G. Glindoni.

Fables by Mr. John Gay. With Memoir by AUSTIN DOBSON, and an Etched Portrait from an unfinished Oil Sketch by Sir Godfrey Kneller.

Select Letters of Percy Bysshe Shelley. Edited, with an Introduction, by RICHARD GARNETT.

The Christian Year. Thoughts in Verse for the Sundays and Holy Days throughout the Year. With Miniature Portrait of the Rev. J. Keble, after a Drawing by G. Richmond, R.A.

Shakspere’s Works. Complete in Twelve Volumes.

Eighteenth Century Essays. Selected and Edited by AUSTIN DOBSON. With a Miniature Frontispiece by R. Caldecott.

Q. Horati Flacci Opera. Edited by F. A. CORNISH, Assistant Master at Eton. With a Frontispiece after a design by L. Alma Tadema, etched by Leopold Lowenstam.

Edgar Allan Poe’s Poems. With an Essay on his Poetry by ANDREW LANG, and a Frontispiece by Linley Sambourne.

Shakspere’s Sonnets. Edited by EDWARD DOWDEN. With a Frontispiece etched by Leopold Lowenstam, after the Death Mask.

English Odes. Selected by EDMUND GOSSE. With Frontispiece on India paper by Hamo Thornycroft, A.R.A.

Of the Imitation of Christ. By THOMAS À KEMPIS. A revised Translation. With Frontispiece on India paper, from a Design by W. B. Richmond.

Poems: Selected from PERCY BYSSHE SHELLEY. Dedicated to Lady Shelley. With a Preface by RICHARD GARNETT and a Miniature Frontispiece.
PARSLOE, Joseph.—Our Railways. Sketches, Historical and Descriptive. With Practical Information as to Fares and Rates, etc., and a Chapter on Railway Reform. Crown 8vo, 6s.


PAULI, Reinhold.—Simon de Montfort, Earl of Leicester, the Creator of the House of Commons. Crown 8vo, 6s.

Paul of Tarsus. By the Author of "Rabbi Jeshua." Crown 8vo, 4s. 6d.

PEMBERTON, T. Edgar.—Charles Dickens and the Stage. A Record of his Connection with the Drama. Crown 8vo, 6s.

PEZZI, Domenico.—Aryan Philology, according to the most recent researches (Glottologia Aria Recentissima). Translated by E. S. Roberts. Crown 8vo, 6s.


Philological Society, Transactions of. Published irregularly. List of Publications on application.

PICCIOTTO, James.—Sketches of Anglo-Jewish History. Demy 8vo, 12s.

Pierce Gambit: Chess Papers and Problems. By JAMES PIERCE, M.A., and W. TIMBRELL PIERCE. Crown 8vo, 6s. 6d.

PIESSE, Charles II.—Chemistry in the Brewing-Room. Being the substance of a Course of Lessons to Practical Brewers. 1 cap., 5s.

PLINY.—The Letters of Pliny the Younger. Translated by J. D. LEWIS. Post 8vo, 5s.


POOLE, W. F.—An Index to Periodical Literature. Third Edition. Royal 8vo, £3 13s. 6d.

POOLE, W. F., and FLETCHER, W. J.—Index to Periodical Literature. First Supplement. 1882 to 1887. Royal 8vo, £1 16s.

Practical Guides.—France, Belgium, Holland, and the Rhine. 1s. Italian Lakes. 1s. Wintering Places of the South. 2s. Switzerland, Savoy, and North Italy. 2s. 6d. General Continental Guide. 5s. Geneva. 1s. Paris. 1s. Bernese Oberland. 1s. Italy. 4s.
A List of


PURITZ, Ludwig.—Code-Book of Gymnastic Exercises. Translated by O. Knofe and J. W. Macqueen. 32mo, 1s. 6d.

RAPSON, Edward J.—The Struggle between England and France for Supremacy in India. Crown 8vo, 4s. 6d.

RAVENSTEIN, E. G., and HULLEY, John.—The Gymnasium and its Fittings. With 14 Plates of Illustrations. 8vo, 2s. 6d.

READE, Winwood.—The Martyrdom of Man. Thirteenth Edition. 8vo, 7s. 6d.


RIDEAL, C. F.—Wellerisms, from "Pickwick" and "Master Humphrey's Clock." 18mo, 2s.


ROBINSON, A. Mary F.—The Fortunate Lovers. Twenty-seven Novels of the Queen of Navarre. Large crown 8vo, 10s. 6d.

ROLFE, Eustace Neville, and INGLEBY, Holcombe.—Naples in 1888. With Illustrations. Crown 8vo, 6s.


ROSS, Percy.—A Professor of Alchemy. Crown 8vo, 3s. 6d.

ROUTLEDGE, James.—English Rule and Native Opinion in India. 8vo, 10s. 6d.


The Revolution in Tanner's Lane. Edited by REUBEN SHAPCOTT. Crown 8vo, 7s. 6d.

Miriam's Schooling; and other Papers. Edited by REUBEN SHAPCOTT. Crown 8vo, 6s.

SAMUELSON, James.—India, Past and Present: Historical, Social, and Political. With a Map, Explanatory Woodcuts and Collotype Views, Portraits, etc., from 30 Photographs. 8vo, 21s.
SAMUELSON, James—continued.


Bulgaria, Past and Present: Historical, Political, and Descriptive. With Map and numerous Illustrations. Demy 8vo, 10s. 6d.

SANDWITH, F. M.—Egypt as a Winter Resort. Crown 8vo, 3s. 6d.

SANTIAGO,E, Daniel.—The Curry Cook's Assistant. Fcap. 8vo, cloth. 1s. 6d.; paper covers, 1s.


SAYWELL, J. L.—New Popular Handbook of County Dialects. Crown 8vo, 5s.


SCHLEICHER, August.—A Compendium of the Comparative Grammar of the Indo-European, Sanskrit, Greek, and Latin Languages. Translated from the Third German Edition by Herbert Bendall. 2 parts. 8vo, 13s. 6d.


SCOTT, Benjamin.—A State Iniquity: Its Rise, Extension, and Overthrow. Demy 8vo, plain cloth, 3s. 6d.; gilt, 5s.

SELBY, H. M.—The Shakespeare Classical Dictionary; or, Mythological Allusions in the Plays of Shakespeare Explained. Fcap. 8vo, 1s.

Selwyn, Bishop, of New Zealand and of Lichfield. A Sketch of his Life and Work, with Further Gleanings from his Letters, Sermons, and Speeches. By the Rev. Canon Curteis. Large crown 8vo, 7s. 6d.

SERJEANT, W. C. Eldon.—The Astrologer's Guide (Anima Astrologiae). Demy 8vo, 7s. 6d.


Shakspere's Works, an Index to. By Evangeline O'Connor. Crown 8vo, 5s.

SHAKESPEARE.—The Bankside Shakespeare. The Comedies, Histories, and Tragedies of Mr. William Shakespeare, as presented at the Globe and Blackfriars Theatres, circa 1591-1623. Being the Text furnished the Players, in parallel pages with the first revised folio text, with Critical Introductions. 8vo.

[In preparation.]
A List of

SHAKESPEARE—continued.

A New Study of Shakespeare. An Inquiry into the Connection of the Plays and Poems, with the Origins of the Classical Drama, and with the Platonic Philosophy, through the Mysteries. Demy 8vo, 10s. 6d.

Shakespeare's Cymbeline. Edited, with Notes, by C. M. Ingleby. Crown 8vo, 1s. 6d.


Shakspere Society (The New).—Subscription, one guinea per annum. List of Publications on application.


SIBREE, James, Jun.—The Great African Island. Chapters on Madagascar. A Popular Account of the Physical Geography, etc., of the Country. With Physical and Ethnological Maps and 4 Illustrations. 8vo, 10s. 6d.

SIGERSON, George, M.D.—Political Prisoners at Home and Abroad. With Appendix on Dietaries. Crown 8vo, 2s. 6d.

SIMCOX, Edith.—Episodes in the Lives of Men, Women, and Lovers. Crown 8vo, 7s. 6d.

SINCLAIR, Thomas.—Essays: in Three Kinds. Crown 8vo, 1s. 6d.; wrappers, 1s.


SINNETT, A. P.—The Occult World. Fourth Edition. Crown 8vo, 3s. 6d.

Incidents in the Life of Madame Blavatsky. Demy 8vo, 10s. 6d.

Skinner, James: A Memoir. By the Author of "Charles Lowder." With a Preface by the Rev. Canon Carter, and Portrait. Large crown, 7s. 6d.

* * * Also a cheap Edition. With Portrait. Fourth Edition. Crown 8vo, 3s. 6d.


<table>
<thead>
<tr>
<th>Author</th>
<th>Title</th>
<th>Publisher/Collection</th>
<th>Edition Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sophocles</td>
<td>The Seven Plays in English Verse. Translated by LEWIS CAMPBELL. Crown 8vo, 7s. 6d.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Specimens of English Prose Style from Malory to Macaulay. Selected and Annotated, with an Introductory Essay, by GEORGE SAINTSBURY. Large crown 8vo, printed on handmade paper, parchment antique or cloth, 12s.; vellum, 15s.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPEDDING, James</td>
<td>The Life and Times of Francis Bacon. 2 vols. Post 8vo, 21s.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spinoza, Benedict de</td>
<td>His Life, Correspondence, and Ethics. By R. WILLIS, M.D. 8vo, 21s.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ST. HILL, Katharine</td>
<td>The Grammar of Palmistry. With 18 Illustrations. 12mo, 1s.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STREET, J. C.</td>
<td>The Hidden Way across the Threshold; or, The Mystery which hath been hidden for Ages and from Generations. With Plates. Large 8vo, 15s.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUMNER, W. G.</td>
<td>What Social Classes owe to Each Other. 12mo, 3s. 6d.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SWINBURNE, Algernon Charles</td>
<td>A Word for the Navy. Imperial 16mo, 5s.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Bibliography of Swinburne, 1857-1887. Crown 8vo, vellum gilt, 6s.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYLVIA, Carmen (Queen of Roumania), The Life of. Translated by Baroness DEICHMANN. With 4 Portraits and 1 Illustration. 8vo, 12s.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leaves from an Egyptian Note-book. Crown 8vo, 5s.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAYLOR, Sir Henry</td>
<td>The Statesman. Fcap. 8vo, 3s. 6d.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A List of

Technological Dictionary of the Terms employed in the Arts and Sciences; Architecture; Engineering; Mechanics; Shipbuilding and Navigation; Metallurgy; Mathematics, etc. Second Edition. 3 vols. 8vo.
- Vol. I. German-English-French. 12s.
- Vol. II. English-German-French. 12s.
- Vol. III. French-German-English. 15s.

THACKERAY, Rev. S. W., LL.D—The Land and the Community. Crown 8vo, 3s. 6d.


Sultan Stork; and other Stories and Sketches. 1829-1844. Now First Collected. To which is added the Bibliography of Thackeray, Revised and Considerably Enlarged. Large demy 8vo, 10s. 6d.

THOMPSON, Sir A.T.—Diet in Relation to Age and Activity. Fcap. 8vo, cloth, 1s. 6d.; paper covers, Is.

Modern Cremation. Crown 8vo, 2s. 6d.

Tobacco Talk and Smokers' Gossip. 16mo, 2s.

TRANT, William.—Trade Unions: Their Origin, Objects, and Efficacy. Small crown 8vo, 1s. 6d.; paper covers, 1s.


An Essay on the Life and Genius of Calderon. With Translations from his "Life's a Dream" and "Great Theatre of the World." Second Edition, Revised and Improved. Extra fcap. 8vo, 5s. 6d.

Gustavus Adolphus in Germany, and other Lectures on the Thirty Years' War. Third Edition, Enlarged. Fcap. 8vo, 4s.


Lectures on Mediæval Church History. Being the Substance of Lectures delivered at Queen's College, London. Second Edition. 8vo, 12s.
TRENCHE, The late R. C., Archbishop—continued.


TRUMBULL, H. Clay.—The Blood-Covenant, a Primitive Rite, and its Bearings on Scripture. Post 8vo, 7s. 6d.

TURNER, Charles Edward.—Count Tolstoi, as Novelist and Thinker. Lectures delivered at the Royal Institution. Crown 8vo, 3s. 6d. The Modern Novelists of Russia. Lectures delivered at the Taylor Institution, Oxford. Crown 8vo, 3s. 6d.

TWEEDIE, Mrs. Alec.—The Ober-Ammergau Passion Play, 1890. Small crown 8vo, 2s. 6d.


VESCELIUS-SHELDON, Louise.—An I. D. B. in South Africa. Illustrated by G. E. Graves and Al. HenckE. Crown 8vo, 7s. 6d.


VINCENT, Frank.—Around and about South America. Twenty Months of Quest and Query. With Maps, Plans, and 54 Illustrations. Medium 8vo, 21s.

WAITE, A. E.—Lives of Alchemystical Philosophers. Demy 8vo, 10s. 6d.

The Magical Writings of Thomas Vaughan. Small 4to, 10s. 6d.

The Real History of the Rosicrucians. With Illustrations. Crown 8vo, 7s. 6d.
WAITE, A. E.—continued.

The Mysteries of Magic. A Digest of the Writings of Éliphas Lévi. With Illustrations. Demy 8vo, 10s. 6d.

WAKE, C. Staniland.—Serpent-Worship, and other Essays, with a Chapter on Totemism. Demy 8vo, 10s. 6d.

The Development of Marriage and Kinship. Demy 8vo, 18s.

Wales.—Through North Wales with a Knapsack. By Four Schoolmistresses. With a Sketch Map. Small crown 8vo, 2s. 6d.

WALL, George.—The Natural History of Thought in its Practical Aspect, from its Origin in Infancy. Demy 8vo, 12s. 6d.


WALPOLE, Chas. George.—A Short History of Ireland from the Earliest Times to the Union with Great Britain. With 5 Maps and Appendices. Third Edition. Crown 8vo, 6s.


WATSON, R. G.—Spanish and Portuguese South America during the Colonial Period. 2 vols. Post 8vo, 21s.


WESTROPP, Hodder M.—Primitive Symbolism as Illustrated in Phallic Worship; or, The Reproductive Principle. With an Introduction by Major-Gen. FORLONG. Demy 8vo, parchment, 7s. 6d.

WHEELDON, J. P.—Angling Resorts near London. The Thames and the Lea. Crown 8vo, paper, 1s. 6d.
WHIBLEY, Chas.—In Cap and Gown: Three Centuries of Cambridge Wit. Crown 8vo, 7s. 6d.

WHITMAN, Sidney.—Imperial Germany. A Critical Study of Fact and Character. Crown 8vo, 7s. 6d.

WIGSTON, W. F. C.—Hermes Stella; or, Notes and Jottings on the Bacon Cipher. 8vo, 6s.

Wilberforce, Bishop of Oxford and Winchester, Life. By his Son REGINALD WILBERFORCE. Crown 8vo, 6s.

WILD RIDGE, T. Tyndall.—The Dance of Death, in Painting and in Print. With Woodcuts. 4to, 3r. 6d.; the Woodcuts coloured by hand, 5s.

WOLTMANN, Dr. Alfred, and WOERMANN, Dr. Karl.—History of Painting. With numerous Illustrations. Medium 8vo. Vol. I. Painting in Antiquity and the Middle Ages. 28s.; bevelled boards, gilt leaves, 30s. Vol. II. The Painting of the Renaissance. 42s.; bevelled boards, gilt leaves, 45s.


WORTHY, Charles.—Practical Heraldry; or, An Epitome of English Armory. 124 Illustrations. Crown 8vo, 7s. 6d.

WRIGHT, Thomas.—The Homes of Other Days. A History of Domestic Manners and Sentiments during the Middle Ages. With Illustrations from the Illuminations in Contemporary Manuscripts and other Sources. Drawn and Engraved by F. W. FAIRHOLT, F.S.A. 350 Woodcuts. Medium 8vo, 21s.


YELVERTON, Christopher.—Oneiros; or, Some Questions of the Day. Crown 8vo, 5s.

THEOLOGY AND PHILOSOPHY.


AMBERLEY, Viscount.—An Analysis of Religious Belief. 2 vols. Demy 8vo, 30s.
A List of


BELANY, Rev. R.—The Bible and the Papacy. Crown 8vo, 2s.


BUNSEN, Ernest de.—Islam; or, True Christianity. Crown 8vo, 5s.


Job and Solomon; or, The Wisdom of the Old Testament. Demy 8vo, 12s. 6d.

The Psalms; or, Book of The Praises of Israel. Translated with Commentary. Demy 8vo. 16s.

CLARKE, James Freeman.—Ten Great Religions. An Essay in Comparative Theology. Demy 8vo, 10s. 6d.

Ten Great Religions. Part II. A Comparison of all Religions. Demy 8vo, 10s. 6d.

COKE, Henry.—Creeds of the Day; or, Collated Opinions of Reputable Thinkers. 2 vols. Demy 8vo, 21s.
Kegan Paul, Trench, Trübner & Co.’s Publications.


The Eight Circulars of Auguste Comte. Translated from the French. Fcap. 8vo, 1s. 6d.

Appeal to Conservatives. Crown 8vo, 2s. 6d.


Idols and Ideals. With an Essay on Christianity. Crown 8vo, 4s.


Salvator Mundi; or, Is Christ the Saviour of all Men? Twelfth Edition. Crown 8vo, 2s. 6d.

The Larger Hope. A Sequel to “Salvator Mundi.” Second Edition. 16mo, 1s.


Balaam. An Exposition and a Study. Crown 8vo, 5s.

Miracles. An Argument and a Challenge. Crown 8vo, 2s. 6d.

**CRANBROOK, James.**—Credibilia; or, Discourses on Questions of Christian Faith. Post 8vo, 3s. 6d.

The Founders of Christianity; or, Discourses upon the Origin of the Christian Religion. Post 8vo, 6s.

**DAWSON, Geo., M.A.**—Prayers, with a Discourse on Prayer. Edited by his Wife. First Series. Tenth Edition. Small Crown 8vo, 3s. 6d.

Prayers, with a Discourse on Prayer. Edited by George St. Clair, F.G.S. Second Series. Small Crown 8vo, 3s. 6d.

Sermons on Disputed Points and Special Occasions. Edited by his Wife. Fourth Edition. Crown 8vo, 3s. 6d.

Sermons on Daily Life and Duty. Edited by his Wife. Fifth Edition. Small crown 8vo, 3s. 6d.


Every-day Counsels. Edited by George St. Clair, F.G.S. Crown 8vo, 6s.

Doubter's Doubt about Science and Religion. Crown 8vo, 3s. 6d.

FICHTE, Johann Gottlieb.—Characteristics of the Present Age. Translated by William Smith. Post 8vo, 6s.
New Exposition of the Science of Knowledge. Translated by A. E. Kroeger. 8vo, 6s.

A Treatise on the Principle of Sufficient Reason. A Psychological Theory of Reasoning, showing the Relativity of Thought to the Thinker, of Recognition to Cognition, the Identity of Presentation and Representation, of Perception and Apperception. Demy 8vo, 6s.


GOUGH, Edward.—The Bible True from the Beginning. A Commentary on all those Portions of Scripture that are most Questioned and Assailed. Vols. I., II., and III. Demy 8vo, 16s. each.

Enigmas of Life. Seventeenth Edition. Post 8vo, 10s. 6d.
Political Problems for our Age and Country. Demy 8vo, 10s. 6d.
Miscellaneous Essays. 2 Series. Crown 8vo, 7s. 6d. each.

The Temple of Humanity, and other Sermons. Crown 8vo, 6s.
GURNEY, Alfred.—Our Catholic Inheritance in the Larger Hope. Crown 8vo, 1s. 6d.

HAINES, C. R.—Christianity and Islam in Spain, A.D. 756-1031. Crown 8vo, 2s. 6d.


Unsectarian Family Prayers. New Edition. Fcap. 8vo, 1s. 6d.


KEMPIS, Thomas.—Of the Imitation of Christ. Parchment Library Edition.—Parchment or cloth, 6s.; vellum, 7s. 6d. The Red Line Edition, fcap. 8vo, cloth extra, 2s. 6d. The Cabinet Edition, small 8vo, cloth limp, 1s.; cloth boards, 1s. 6d. The Miniature Edition, cloth limp, 32mo, 1s.; or with red lines, 1s. 6d.


Notes of a Visit to the Scenes in which his Life was spent. With numerous Illustrations. By F. R. CRUISE, M.D. Demy 8vo, 12s.

Keys of the Creeds (The). Third Revised Edition. Crown 8vo, 2s. 6d.


LEWIS, Harry S.—Targum on Isaiah i.—v. With Commentary. Demy 8vo, 5s.

MANNING, Cardinal.—Towards Evening. Selections from his Writings. Third Edition. 16mo, 2s.

MARTINEAU, James.—Essays, Philosophical and Theological. 2 vols. Crown 8vo, £1 4s.


Meditations on Death and Eternity. Translated from the German by FREDERICA ROWAN. Published by Her Majesty's gracious permission. Crown 8vo, 6s.
Meditations on Life and its Religious Duties. Translated from the German by Frederica Rowan. Published by Her Majesty's gracious permission. Being the Companion Volume to "Meditations on Death and Eternity." Crown 8vo, 6s.

NEVILL, F.—Retrogression or Development. Crown 8vo, 3s. 6d.

NICHOLS, J. Broadhurst, and DYMOND, Charles William.—Practical Value of Christianity. Two Prize Essays. Crown 8vo, 3s. 6d.


The Collected Works of Theodore Parker, Minister of the Twenty-eighth Congregational Society at Boston, U.S. In 14 vols. 8vo, 6s. each.


Plea for Truth in Religion. Crown 8vo, 2s. 6d

Psalms of the West. Small crown 8vo, 5s.


Pulpit Commentary, The—continued.


Pulpit Commentary, The—continued.


Pulpit Commentary, The. (New Testament Series.)


Pulpit Commentary, The—continued.


Pusey, Dr.—Sermons for the Church's Seasons from Advent to Trinity. Selected from the Published Sermons of the late Edward Bouverie Pusey, D.D. Crown 8vo, 5s.

Renan, Ernest.—Philosophical Dialogues and Fragments. From the French. Post 8vo, 7s. 6d.

An Essay on the Age and Antiquity of the Book of Nabathaean Agriculture. Crown 8vo, 3s. 6d.

The Life of Jesus. Crown 8vo, cloth, 1s. 6d.; paper covers, 1s.

The Apostles. Crown 8vo, cloth, 1s. 6d.; paper covers, 1s.

REYNOLDS, Rev. J. W.—continued.


The Mystery of the Universe our Common Faith. Demy 8vo, 14s.

The World to Come: Immortality a Physical Fact. Crown 8vo, 6s.

RICHARDSON, Austin.—"What are the Catholic Claims?"

RIVINGTON, Luke.—Authority, or a Plain Reason for joining the Church of Rome. Fifth Edition. Crown 8vo, 3s. 6d.

Dependence; or, The Insecurity of the Anglican Position. Crown 8vo, 5s.

Edited by the Rev. Stopford Brooke, M.A.
I. Two vols., uniform with the Sermons. With Steel Portrait. Crown 8vo, 7s. 6d.
II. Library Edition, in Demy 8vo, with Portrait. 12s.

Sermons. Five Series. Small crown 8vo, 3s. 6d. each.

Notes on Genesis. New and Cheaper Edition. Small crown 8vo, 3s. 6d.


Lectures and Addresses, with other Literary Remains. A New Edition. Small crown 8vo, 5s.

An Analysis of Tennyson’s "In Memoriam." (Dedicated by Permission to the Poet-Laureate.) Fcap. 8vo, 2s.

The Education of the Human Race. Translated from the German of Gotthold Ephraim Lessing. Fcap. 8vo, 2s. 6d.

** A Portrait of the late Rev. F. W. Robertson, mounted for framing, can be had, 2s. 6d.


SHEEPSHANKS, Rev. J.—Confirmation and Unction of the Sick. Small crown 8vo, 3s. 6d.

STEPHEN, Caroline E.—Quaker Strongholds. Crown 8vo, 5s.

Theology and Piety alike Free; from the Point of View of Manchester New College, Oxford. A Contribution to its effort offered by an old Student. Demy 8vo, 9s.
TRENCH, Archbishop.—Notes on the Parables of Our Lord. 8vo, 12s. Cheap Edition. Fifty-sixth Thousand. 7s. 6d.

Notes on the Miracles of Our Lord. 8vo, 12s. Cheap Edition. Forty-eighth Thousand. 7s. 6d.

Studies in the Gospels. Fifth Edition, Revised. 8vo, 10s. 6d.

Brief Thoughts and Meditations on Some Passages in Holy Scripture. Third Edition. Crown 8vo, 3s. 6d.


Sermons New and Old. Crown 8vo, 6s.

Westminster and other Sermons. Crown 8vo, 6s.


Commentary on the Epistles to the Seven Churches in Asia. Fourth Edition, Revised. 8vo, 8s. 6d.

The Sermon on the Mount. An Exposition drawn from the Writings of St. Augustine, with an Essay on his Merits as an Interpreter of Holy Scripture. Fourth Edition, Enlarged. 8vo, 10s. 6d.

Shipwrecks of Faith. Three Sermons preached before the University of Cambridge in May, 1867. Fcap. 8vo, 2s. 6d.


WARD, Wilfrid.—The Wish to Believe. A Discussion Concerning the Temper of Mind in which a reasonable Man should undertake Religious Inquiry. Small crown 8vo, 5s.


What is Truth? A Consideration of the Doubts as to the Efficacy of Prayer, raised by Evolutionists, Materialists, and others. By "Nemo."


ENGLISH AND FOREIGN PHILOSOPHICAL LIBRARY.

Auguste Comte and Positivism. By the late John Stuart Mill. Third Edition. 3s. 6d.

Candid Examination of Theism (A). By Physicus. Second Edition. 7s. 6d.

Colour-Sense (The): Its Origin and Development. An Essay in Comparative Psychology. By Grant Allen. 10s. 6d.

Contributions to the History of the Development of the Human Race. Lectures and Dissertations. By Lazarus Geiger. Translated from the German by D. Asher. 6s.


Dr. Appleton: His Life and Literary Relics. By J. H. Appleton and A. H. Sayce. 10s. 6d.

Edgar Quinet: His Early Life and Writings. By Richard Heath. With Portraits, Illustrations, and an Autograph Letter. 12s. 6d.

Emerson at Home and Abroad. By M. D. Conway. With Portrait. 10s. 6d.


Essays and Dialogues of Giacomo Leopardi. Translated by Charles Edwardes. With Biographical Sketch. 7s. 6d.

Essence of Christianity (The). By L. Feuerbach. Translated from the German by Marian Evans. Second Edition. 7s. 6d.

Ethic Demonstrated in Geometrical Order and Divided into Five Parts, which treat (1) Of God, (2) Of the Nature and Origin of the Mind, (3) Of the Origin and Nature of the Affects, (4) Of Human Bondage, or of the Strength of the Affects, (5) Of the Power of the Intellect, or of Human Liberty. By Benedict de Spinoza. Translated from the Latin by William Hale White. 10s. 6d.

Guide of the Perplexed of Maimonides (The). Translated from the Original Text and Annotated by M. Friedlander. 3 vols. 31s. 6d.

History of Materialism (A), and Criticism of its present Importance. By Prof. F. A. Lange. Authorized Translation from the German by Ernest C. Thomas. In 3 vols. 10s. 6d. each.

Johann Gottlieb Fichte's Popular Works. The Nature of the Scholar; The Vocation of the Scholar; The Vocation of Man; The Doctrine of Religion; Characteristics of the Present Age; Outlines of the Doctrine of Knowledge. With a Memoir by William Smith, LL.D. 2 vols. 21s.
Moral Order and Progress. An Analysis of Ethical Conceptions. 
By S. Alexander. 14s.

Natural Law. An Essay in Ethics. By Edith Simcox. Second 
Edition. 10s. 6d.

Outlines of the History of Religion to the Spread of the 
Universal Religions. By Prof. C. P. Tiele. Translated 
7s. 6d.

Philosophy of Law (The). By Prof. Diodato Lioy. Translated 
by W. Hastie.

Philosophy of Music (The). Lectures delivered at the Royal Insti-
tution of Great Britain. By William Pole, F.R.S. Second 
Edition. 7s. 6d.

Philosophy of the Unconscious (The). By Eduard Von 
Hartmann. Translated by William C. Coupland. 3 vols. 
31s. 6d.

Religion and Philosophy in Germany. A Fragment. By 
Heinrich Heine. Translated by J. Snodgrass. 6s.

Religion in China. Containing a brief Account of the Three 
Religions of the Chinese; with Observations on the Prospects 
of Christian Conversion amongst that People. By Joseph Edkins, 
D.D. Third Edition. 7s. 6d.

Science of Knowledge (The). By J. G. Fichte. Translated from 
the German by A. E. Kroeger. With an Introduction by Prof. 
W. T. Harris. 10s. 6d.

Science of Rights (The). By J. G. Fichte. Translated from the 
German by A. E. Kroeger. With an Introduction by Prof. 
W. T. Harris. 12s. 6d.

World as Will and Idea (The). By Arthur Schopenhauer. 
Translated from the German by R. B. Haldane and John 
Kemp. 3 vols. £2 10s.

Extra Series.

Abraham Fornander. 3 vols. 27s.

Lessing: His Life and Writings. By James Sime. Second Edition, 
2 vols. With Portraits. 21s.

Oriental Religions, and their Relation to Universal Religion—India. 
By Samuel Johnson. 2 vols. 21s.
A List of

SCIENCE.

BADER, C.—The Natural and Morbid Changes of the Human Eye, and their Treatment. Medium 8vo, 16s.


BICKNELL, C.—Flowering Plants and Ferns of the Riviera and Neighbouring Mountains. Drawn and described by C. BICKNELL. With 82 full-page Plates, containing Illustrations of 350 Specimens. Imperial 8vo, half-roan, gilt edges, £3 3s.

BLATER, Joseph.—Table of Quarter-Squares of all Whole Numbers from 1 to 200,000. For Simplifying Multiplication, Squaring, and Extraction of the Square Root. Royal 4to, half-bound, 21s.

Table of Napier. Giving the Nine Multiples of all Numbers. Cloth case, 1s. 3d.


BUNGE, G.—Text-Book of Physiological and Pathological Chemistry. For Physicians and Students. Translated from the German by L. C. WOODBRIDGE, M.D. Demy 8vo, 16s.

CALLEJA, Camilo, M.D.—Principles of Universal Physiology. Crown 8vo, 3s. 5d.

CANDLER, C.—The Prevention of Consumption: A New Theory of the Nature of the Tubercle-Bacillus. Demy 8vo, 10s. 6d.

The Prevention of Measles. Crown 8vo, 5s.


Nature and Man. With a Memorial Sketch by the Rev. J. ESTLIN CARPENTER. Portrait. Large crown 8vo, 8s. 6d.

COTTA, B. von.—Geology and History. A Popular Exposition of all that is known of the Earth and its Inhabitants in Pre-historic Times. 12mo, 2s.

DANA, James D.—A Text-Book of Geology, designed for Schools and Academies. Illustrated. Crown 8vo, 10s.

Manual of Geology. Illustrated by a Chart of the World, and over 1000 Figures. 8vo, 21s.
DANA, James D.—continued.
The Geological Story Briefly Told. Illustrated. 12mo, 7s. 6d.
A System of Mineralogy. By J. D. DANA, aided by G. J. BRUSH. Fifth Edition. Royal 8vo, £2 2s.
DU MONCEL, Count.—The Telephone, the Microphone, and the Phonograph. With 74 Illustrations. Third Edition. Small crown 8vo, 5s.
DYMOCK, W.—The Vegetable Materia Medica of Western India. 4 Parts. 8vo, 5s. each.
Education: Scientific and Technical; or, How the Inductive Sciences are Taught, and How they Ought to be Taught. 8vo, 10s. 6d.
A Visit to Ceylon. Post 8vo, 7s. 6d.
HENWOOD, William Jory.—The Metalliferous Deposits of Cornwall and Devon. With Appendices on Subterranean Temperature; the Electricity of Rocks and Veins; the Quantities of Water in the Cornish Mines; and Mining Statistics. With 113 Tables, and 12 Plates, half-bound. 8vo, £2 2s.

Observations on Metalliferous Deposits, and on Subterranean Temperature. In 2 Parts. With 38 Tables, 31 Engravings on Wood, and 6 Plates. 8vo, £1 16s.


HULME, F. Edward.—Mathematical Drawing Instruments, and How to Use Them. With Illustrations. Third Edition. Imperial 16mo, 3s. 6d.


KINAHAN, G. H.—Valleys and their Relation to Fissures, Fractures, and Faults. Crown 8vo, 7s. 6d.

KLEIN, Felix.—Lectures on the Ikosahedron, and the Solution of Equations of the Fifth Degree. Translated by G. G. MORRICE. Demy 8vo, 10s. 6d.


LIVERSIDGE, A.—The Minerals of New South Wales, etc. With large Coloured Map. Royal 8vo, 18s.

MIVART, St. George.—On Truth. Demy 8vo, 16s.

The Origin of Human Reason. Demy 8vo, 10s. 6d.


Elementary Bandaging and Surgical Dressing. For the Use of Dressers and Nurses. 18mo, 2s.

RAMSAY, E. P.—Tabular List of all the Australian Birds at present known to the Author. Crown 4to, 12s. 6d,

English Psychology. Crown 8vo, 7s. 6d.

RODD, Edward Hearle.—The Birds of Cornwall and the Scilly Islands. Edited by J. E. Harting. With Portrait and Map. 8vo, 14s.

ROMANES, G. J.—Mental Evolution in Animals. With a Posthumous Essay on Instinct by CHARLES DARWIN, F.R.S. Demy 8vo, 12s.

Mental Evolution in Man: Origin of Human Faculty. Demy 8vo, 14s.


Pyrology, or Fire Chemistry. Small 4to, 36s.


Tea, Coffee, and Cocoa. A Practical Treatise on the Analysis of Tea, Coffee, Cocoa, Chocolate, Mate (Paraguay Tea). Crown 8vo, 5s.


**WRIGHT, G. Frederick, D.D.**—The Ice Age in North America, and its bearing upon the Antiquity of Man. With Maps and Illustrations. 8vo, 21s.

---

**THE INTERNATIONAL SCIENTIFIC SERIES.**

I. Forms of Water in Clouds and Rivers, Ice and Glaciers.  

II. Physics and Politics; or, Thoughts on the Application of the Principles of "Natural Selection" and "Inheritance" to Political Society. By Walter Bagehot. Eighth Edition. 5s.


V. The Study of Sociology. By Herbert Spencer. Fourteenth Edition. 5s.


VII. Animal Locomotion; or, Walking, Swimming, and Flying. By J. B. Pettigrew, M.D., F.R.S., etc. With 130 Illustrations. Third Edition. 5s.

VIII. Responsibility in Mental Disease. By Henry Maudsley, M.D. Fourth Edition. 5s.


XII. The Doctrine of Descent and Darwinism. By Professor Oscar Schmidt. With 26 Illustrations. Seventh Edition. 5s.


XV. The Chemistry of Light and Photography. By Dr. Hermann Vogel. With 100 Illustrations. Fifth Edition. 5s.

XVI. The Life and Growth of Language. By Professor William Dwight Whitney. Fifth Edition. 5s.


XXV. Education as a Science. By Alexander Bain, LL.D. Seventh Edition. 5s.

XXVI. The Human Species. By Professor A. de Quatrefages. Fifth Edition. 5s.


XXIX. The Brain as an Organ of Mind. By H. Charlton Bastian, M.D. With numerous Illustrations. Third Edition. 5s.


XXXII. General Physiology of Muscles and Nerves. By Professor J. Rosenthal. Third Edition. With 75 Illustrations. 5s.


XXXIX. The Sun. By Professor Young. With Illustrations. Third Edition. 5s.


XLVII. The Organs of Speech and their Application in the Formation of Articulate Sounds. By Georg Hermann Von Meyer. With 47 Woodcuts. 5s.


LII. Physical Expression: Its Modes and Principles. By Francis Warner, M.D., F.R.C.P., Hunterian Professor of Comparative Anatomy and Physiology, R.C.S.E. With 50 Illustrations. 5s.

LIII. Anthropoid Apes. By Robert Hartmann. With 63 Illustrations. 5s.

LIV. The Mammalia in their Relation to Primeval Times. By Oscar Schmidt. With 51 Woodcuts. 5s.

LV. Comparative Literature. By H. Macaulay Posnett, LL.D. 5s.


LVII. Microbes, Ferments, and Moulds. By E. L. Trouessart. With 107 Illustrations. 5s.

LVIII. Geographical and Geological Distribution of Animals. By Professor A. Heilprin. With Frontispiece. 5s.


LXI. Manual of British Discomycetes, with descriptions of all the Species of Fungi hitherto found in Britain included in the Family, and Illustrations of the Genera. By William Phillips, F.L.S. 5s.

LXII. International Law. With Materials for a Code of International Law. By Professor Leone Levi. 5s.

LXIII. The Geological History of Plants. By Sir J. William Dawson. With 80 Figures. 5s.

LXIV. The Origin of Floral Structures through Insect and other Agencies. By Rev. Professor G. Henslow. With 88 Illustrations. 5s.


LXVI. The Primitive Family: Its Origin and Development. By C. N. Starcke. 5s.

LXVII. Physiology of Bodily Exercise. By Fernand Lagrange, M.D. 5s.
A List of

LXVIII. The Colours of Animals: their Meaning and Use, especially considered in the Case of Insects. By E. B. Poulton, F.R.S. With Coloured Frontispiece and 66 Illustrations in Text. 5s.

LXIX. Introduction to Fresh-Water Algae. With an Enumeration of all the British Species. By M. C. Cooke. 13 Plates. 5s.

---

**ORIENTAL, EGYPTIAN, ETC.**

**AHLWARDT, W.**—The Divans of the Six Ancient Arabic Poets, Ennâbiga, 'Antara, Tharafa, Zuhair, 'Ala'quama, and Imruulquais. Edited by W. AHLWARDT. Demy 8vo, 12s.

**ALABASTER, Henry.**—The Wheel of the Law: Buddhism illustrated from Siamese Sources. Demy 8vo, 14s.

**ALI, Moulavi Cherâgh.**—The Proposed Political, Legal, and Social Reforms in the Ottoman Empire and other Mohammedan States. Demy 8vo, 8s.

**ARNOLD, Sir Edwin, C.S.I.**—With Sa'di in the Garden; or, The Book of Love. Being the “Ishk,” or Third Chapter of the “Bostân” of the Persian Poet Sa’di. Embodied in a Dialogue held in the Garden of the Taj Mahal, at Agra. Crown 8vo, 7s. 6d.


India Revisited. With 32 Full-page Illustrations. From Photographs selected by the Author. Crown 8vo, 7s. 6d.

The Light of Asia; or, The Great Renunciation. Being the Life and Teaching of Gautama, Prince of India, and Founder of Buddhism. With Illustrations and a Portrait of the Author. Post 8vo, cloth, gilt back and edges; or half-parchment, cloth sides, 3s. 6d. Library Edition. Crown 8vo, 7s. 6d. Illustrated Edition. Small 4to, 21s.


Indian Idylls. From the Sanskrit of the Mahâbhârata. Crown 8vo, 7s. 6d.


The Iliad and Odyssey of India. Fcap. 8vo, 1s.

A Simple Translitteral Grammar of the Turkish Language. Post 8vo, 2s. 6d.

Asiatic Society.—Journal of the Royal Asiatic Society of Great Britain and Ireland, from the Commencement to 1863. First Series, complete in 20 vols. 8vo, with many Plates, £10, or in parts from 4s. to 6s. each.


Asiatic Society—continued.


Auctores Sanscriti:—

Vol. I. The Jaiminīya-Nyāya-Mālā-Vistara. Edited under the supervision of THEODOR GOLDSTÜCKER. Large 4to, £3 13s. 6d.

Vol. II. The Institutes of Gautama. Edited, with an Index of Words, by A. F. STENZLER, Ph.D., Prof. of Oriental Languages in the University of Breslau. 8vo, cloth, 4s. 6d.; stitched, 3s. 6d.

Vol. III. Vaitāna Sutra: The Ritual of the Atharva Veda. Edited, with Critical Notes and Indices, by Dr. R. GARBE. 8vo, 5s.

Vols. IV. and V. Vardhamana's Ganaratnamahodadhi, with the Author's Commentary. Edited, with Critical Notes and Indices, by JULIUS EGGELING. Part I. 8vo, 6s. Part II. 8vo, 6s.


BADGER, George Percy, D.C.L.—An English–Arabic Lexicon. In which the equivalent for English Words and Idiomatic Sentences are rendered into literary and colloquial Arabic. Royal 4to, 8os.


Taoist Texts, Ethical, Political, and Speculative. Imperial 8vo, 10s. 6d.

Leaves from my Chinese Scrap–Book. Post 8vo, 7s. 6d.

First Lessons in Sanskrit Grammar; together with an Introduction to the Hitopadesa. Fourth Edition. 8vo, 3s. 6d.

BEAL, S.—A Catena of Buddhist Scriptures from the Chinese. 8vo, 15s.


Buddhist Literature in China. Four Lectures. Demy 8vo, 10s. 6d.

BEAMES, John.—Outlines of Indian Philology. With a Map showing the Distribution of Indian Languages. Second enlarged Edition. Crown 8vo, 5s.

A Comparative Grammar of the Modern Aryan Languages of India: Hindi, Panjabi, Sindhi, Gujarati, Marathi, Oriya, and Bengali. 3 vols. 16s. each.

BELLEW, Deputy-Surgeon-General H. W.—The History of Cholera in India from 1862 to 1881. With Maps and Diagrams. Demy 8vo, £2 2s.

A Short Practical Treatise on the Nature, Causes, and Treatment of Cholera. Demy 8vo, 7s. 6d.

From the Indus to the Tigris. A Narrative of a Journey through Balochistan, Afghanistan, Khorassan, and Iran, in 1872. 8vo, 10s. 6d.

Kashmir and Kashghar. A Narrative of the Journey of the Embassy to Kashghar in 1873-74. Demy 8vo, 10s. 6d.

The Races of Afghanistan. Being a Brief Account of the Principal Nations inhabiting that Country. 8vo, 7s. 6d.

BELLOWS, John.—English Outline Vocabulary, for the Use of Students of the Chinese, Japanese, and other Languages. Crown 8vo, 6s.

BENFEY, Theodor.—A Practical Grammar of the Sanskrit Language, for the Use of Early Students. Second Edition. Royal 8vo, 10s. 6d.

BENTLEY, W. Holman.—Dictionary and Grammar of the Kongo Language, as spoken at San Salvador, the Ancient Capital of the Old Kongo Empire, West Africa. Demy 8vo, 21s.

BEVERIDGE, H.—The District of Bakarganj: Its History and Statistics. 8vo, 21s.

Buddhist Catechism (A); or, Outline of the Doctrine of the Buddha Gotama. By SUBHADRA BHIKSHU. 12mo, 2s.
BUDGE, Ernest A.—Archaic Classics. Assyrian Texts; being Extracts from the Annals of Shalmaneser II., Sennacherib, and Assur-Bani-Pal. With Philological Notes. Small 4to, 7s. 6d.

BURGESS, James.—Archæological Survey of Western India:—

Reports—
The Belgâm and Kaladi Districts. With 56 Photographs and Lithographic Plates. Royal 4to, half-bound, £2 2s.

The Antiquities of Kâthiâwâd and Kachh. Royal 4to, with 74 Plates. Half-bound, £3 3s.

The Antiquities in the Bidar and Aurangabad Districts, in the Territories of His Highness the Nizam of Haiderabad. With 63 Photographic Plates. Royal 4to, half-bound, £2 2s.

The Buddhist Cave-Temples and their Inscriptions. Containing Views, Plans, Sections, and Elevation of Façades of Cave-Temples; Drawings of Architectural and Mythological Sculptures; Facsimiles of Inscriptions, etc.; with Descriptive and Explanatory Text, and Translations of Inscriptions. With 86 Plates and Woodcuts. Royal 4to, half-bound, £3 3s.

Elura Cave-Temples, and the Brahmanical and Jaina Caves in Western India. With 66 Plates and Woodcuts. Royal 4to, half-bound, £3 3s.

Archeological Survey of Southern India:—

Reports of the Amaravati and Jaggaypyaeta Buddhist Stupas. Containing numerous Collotype and other Illustrations of Buddhist Sculpture and Architecture, etc., in South-Eastern India; Facsimiles of Inscriptions, etc.; with Descriptive and Explanatory Text. Together with Transcriptions, Translations, and Elucidations of the Dhauli and Jaguda Inscriptions of Asoka, by Professor G. Buhler, LL.D. Vol. I. With numerous Plates and Woodcuts. Royal 4to, half-bound, £4 4s.

BURGESS, James.—Epigraphia Indica and Record of the Archæological Survey of India. Edited by Jas. Burgess, LL.D. Parts I., II., and III. Royal 4to, wrappers, 7s. each.

BURNELL, A. C.—Elements of South Indian Palæography, from the Fourth to the Seventeenth Century A.D. Being an Introduction to the Study of South Indian Inscriptions and MSS. Second enlarged and improved Edition. Map and 35 Plates. 4to, £2 12s. 6d.

A Classified Index to the Sanskrit MSS. in the Palace at Tanjore. Prepared for the Madras Government. 3 Parts, 4to, 10s. each.
Kegan Paul, Trench, Trübner & Co.'s Publications.


Cappeller, Carl.—A Sanskrit-English Dictionary. Based upon the St. Petersburg Lexicons. Royal 8vo. [In preparation.

Chalmers, J.—Structure of Chinese Characters, under 300 Primary Forms, after the Shwoh-wan, 100 A.D. Demy 8vo, 12s. 6d.


Chatterji, Mohini M.—The Bhagavad Gîtâ; or, The Lord's Lay. With Commentary and Notes. Translated from the Sanskrit. Second Edition. Royal 8vo, 10s. 6d.

Childers, R. C.—A Pali-English Dictionary, with Sanskrit Equivalents. Imperial 8vo, £3 3s.

The Classical Poetry of the Japanese. Post 8vo, 7s. 6d.

Handbook of Colloquial Japanese. 8vo, 12s. 6d.

Chintamon, H.—A Commentary on the Text of the Bhagavad-Gîtâ; or, The Discourse between Khrishna and Arjuna of Divine Matters. Post 8vo, 6s.

Coomaraswamy, Mutu.—The Dathavansa; or, The History of the Tooth Relic of Gotama Buddha, in Pali Verse. Edited by Mutu Coomaraswamy. Demy 8vo, 10s. 6d. English Translation. With Notes. 6s.

Sutta Nipata; or, Dialogues and Discourses of Gotama Buddha. Translated from the original Pali. Crown 8vo, 6s.

Cowell, E. B.—A Short Introduction to the Ordinary Prakrit of the Sanskrit Dramas. Crown 8vo, 3s. 6d.

Prakrita-Prakasa; or, The Prakrit Grammar of Vararuchi, with the Commentary (Manorama) of Bhamaha. 8vo, 14s.

Craven, T.—English-Hindustani and Hindustani-English Dictionary. 18mo, 3s. 6d.

Cunningham, Major-General Alexander.—The Ancient Geography of India. I. The Buddhist Period, including the Campaigns of Alexander and the Travels of Hwen-Thsang. With 13 Maps. 8vo, £1 8s.

Archæological Survey of India, Reports. With numerous Plates. Vols. I. to XXIII. Royal 8vo, 10s. and 12s. each.

General Index to Vols. I. to XXIII. Royal 8vo, 12s.
A List of

CUST, R. N.—Pictures of Indian Life, Sketched with the Pen from 1852 to 1881. With Maps. Crown 8vo, 7s. 6d.

DENNYS, N. B.—The Folk-Lore of China, and its Affinities with that of the Aryan and Semitic Races. 8vo, 10s. 6d.


The Life of Jenghiz Khan. Translated from the Chinese. Crown 8vo, 5s.

DOWSON, John.—A Grammar of the Urdū or Hindūstānī Language. Second Edition. Crown 8vo, 10s. 6d.

A Hindūstānī Exercise Book. Containing a Series of Passages and Extracts adapted for Translation into Hindūstānī. Crown 8vo, 2s. 6d.

DUKA, Theodore.—An Essay on the Brāhūṇ Grammar. Demy 8vo, 3s. 6d.


EDKINS, Joseph.—China's Place in Philology. An Attempt to show that the Languages of Europe and Asia have a common origin. Crown 8vo, 10s. 6d.

The Evolution of the Chinese Language. As Exemplifying the Origin and Growth of Human Speech. Demy 8vo, 4s. 6d.

The Evolution of the Hebrew Language. Demy 8vo, 5s.

Introduction to the Study of the Chinese Characters. Royal 8vo, 18s.

Egypt Exploration Fund:—


Naukratis. Part II. By ERNEST A. GARDNER. With an Appendix by F. LL. GRIFFITH. With 24 Plates. Royal 4to, 25s.


**The History of India, as told by its own Historians.** The Muhammadan Period. Edited from the Posthumous Papers of the late Sir H. M. ELLIOT. Revised and continued by Professor JOHN DOWSON. 8 vols. 8vo, 8s 8d.

**EMERSON, Ellen Russell.**—Indian Myths; or, Legends, Traditions, and Symbols of the Aborigines of America. Illustrated. Post 8vo, 1s 11d.

**FERGUSSON, T.**—Chinese Researches. First Part. Chinese Chronology and Cycles. Crown 8vo, 10s. 6d.

**FINN, Alexander.**—Persian for Travellers. Oblong 32mo, 5s.

**FRYER, Major G. E.**—The Khyeng People of the SandoWay District, Arakan. With 2 Plates. 8vo, 3s. 6d.

**Páli Studies.** No. I. Analysis, and Páli Text of the Subodhâlankara, or Easy Rhetoric, by Sangharakkhita Thera. 8vo, 3s. 6d.

**GHOSE, Loke N.**—The Modern History of the Indian Chiefs, Rajas, etc. 2 vols. Post 8vo, 21s.

**GILES, Herbert A.**—Chinese Sketches. 8vo, 10s. 6d.

A Dictionary of Colloquial Idioms in the Mandarin Dialect. 4to, 28s.

Synoptical Studies in Chinese Character. 8vo, 15s.

**Chinese without a Teacher.** Being a Collection of Easy and Useful Sentences in the Mandarin Dialect. With a Vocabulary. 12mo, 5s.

The San Tzu Ching; or, Three Character Classic; and the Ch'Jen Tsu Wen; or, Thousand Character Essay. Metrically translated by HERBERT A. GILES. 12mo, 2s. 6d.

**GOVER, C. E.**—The Folk-Songs of Southern India. Containing Canarese, Badaga, Coorg, Tamil, Malayalam, and Telugu Songs. The Cural. 8vo, 10s. 6d.

**GRIFFIN, L. H.**—The Rajas of the Punjab. History of the Principal States in the Punjab, and their Political Relations with the British Government. Royal 8vo, 21s.

**GRIFFITH, F. L.**—The Inscriptions of Siut and Der Rifeh. With 21 Plates. 4to, 10s.
<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Edition</th>
<th>Binding</th>
<th>Price</th>
</tr>
</thead>
</table>


The Indian Musalmans. Third Edition. 8vo, 10s. 6d.

Famine Aspects of Bengal Districts. A System of Famine Warnings. Crown 8vo, 7s. 6d.

A Statistical Account of Bengal. In 20 vols. 8vo, half-morocco, £5.

A Statistical Account of Assam. 2 vols. With 2 Maps. 8vo, half-morocco, 10s.


India.—Publications of the Geographical Department of the India Office, London. A separate list, also list of all the Government Maps, on application.

India.—Publications of the Geological Survey of India. A separate list on application.

India Office Publications:—

Aden, Statistical Account of. 5s.

Baden Powell. Land Revenues, etc., in India. 12s.

Do. Jurisprudence for Forest Officers. 12s.

Beal’s Buddhist Tripitaka. 4s.

Bombay Code. 21s.


Do. do. Vols. III. to VII., and X., XI., XII., XIV., XVI. 8s. each.

Do. do. Vols. XXI., XXII., and XXIII. 9s. each.

Burgess’ Archaeological Survey of Western India.

Vol. II. 63s.

Do. do. do. Vol. III. 42s.

Do. do. Vols. IV. and V. 126s.

Do. do. Southern India.

Vol. I. 84s.

Burma (British) Gazetteer. 2 vols. 50s.
List of India Office Publications—continued.


Cunningham's Archæological Survey. Vols. I. to XXIII. 10s. and 12s. each.

Do. Index to Vols. I. to XXIII. 12s.

Finance and Revenue Accounts of the Government of India for 1883-4. 2s. 6d.

Gamble. Manual of Indian Timbers. 10s.

Indian Education Commission, Report of the. 12s. Appendices. 10 vols. 10s.

Jaschke's Tibetan-English Dictionary. 30s.

Liotard's Silk in India. Part I. 2s.

Loth. Catalogue of Arabic MSS. 10s. 6d.

Markham's Abstract of Reports of Surveys. 1s. 6d.

Mitra (Rajendralala), Buddha Gaya. 60s.

Moir. Torrent Regions of the Alps. 1s.

Mueller. Select Plants for Extra-Tropical Countries. 8s.

Mysore and Coorg Gazetteer. Vols. I. and II. 10s. each.

Do. do. Vol. III. 5s.

N. W. P. Gazetteer. Vols. I. and II. 10s. each.

Do. do. Vols. III. to XI., XIII. and XIV. 12s. each.

Oudh ; do. Vols. I. to III. 10s. each.

Rajputana Gazetteer. 3 vols. 15s.

Saunders' Mountains and River Basins of India. 3s.

Taylor. Indian Marine Surveys. 2s. 6d.

Trigonometrical Survey, Synopsis of Great. Vols. I. to VI. 10s. 6d. each.

Trumpp’s Adi Granth. 52s. 6d.

Waring. Pharmacopœia of India (The). 6s.

Watson’s Tobacco. 5s.


Part II. Coins of the Urtuki Turkumans. By Stanley Lane Poole. With 6 Plates. 9s. Part III. The Coinage of Lydia
International Numismata Orientalia (The)—continued.


Vol. I. Containing the first six parts, as specified above. Royal 4to, half-bound, £3 13s. 6d.


JÄSCHKE, H. A.—A Tibetan-English Dictionary. With special reference to the Prevailing Dialects. To which is added an English-Tibetan Vocabulary. Imperial 8vo, £1 10s.


JENNINGS, Hargrave.—The Indian Religions; or, Results of the Mysterious Buddhism. Demy 8vo, 10s. 6d.


KISTNER, Otto.—Buddha and his Doctrines. A Bibliographical Essay. 4to, 2s. 6d.

KNOWLES, J. H.—Folk-Tales of Kashmir. Post 8vo, 16s.

KOLBE, F. W.—A Language-Study based on Bantu; or, An Inquiry into the Laws of Root-Formation. Demy 8vo, 6s.

KRAPF, L.—Dictionary of the Suahili Language. 8vo, 30s.

LEGGE, James—continued.


Buddhism in Christendom; or, Jesus the Essene. With Illustrations. Demy 8vo, 6s.

LOBSCHEID, W.—Chinese and English Dictionary, arranged according to the Radicals. Imperial 8vo, £2 8s.

English and Chinese Dictionary, with the Punti and Mandarin Pronunciation. Folio, £8 8s.


MARSDEN, William.—Numismata Orientalia Illustrata: The Plates of the Oriental Coins, Ancient and Modern, of the Collection of the late William Marsden, F.R.S. Engraved from Drawings made under his Directions. 57 Plates. 4to, 31s. 6d.


Megha-Duta (The). (Cloud Messenger.) By KALIDĀSA. Translated from the Sanskrit into English Verse by the late H. H. Wilson, F.R.S. The Vocabulary by Francis Johnson. New Edition. 4to, 10s. 6d.

MOCKLER, E.—A Grammar of the Baloochee Language, as it is spoken in Makran (Ancient Gedrosia), in the Persia-Arabic and Roman characters. Fcap. 8vo, 5s.

MUIR, John.—Original Sanskrit Texts, on the Origin and History of the People of India. Translated by John Muir, LL.D.
MUIR, John—continued.


Vol. III. The Vedas: Opinions of their Authors, and of later Indian Writers, on their Origin, Inspiration, and Authority. Second Edition. 8vo, 16s.

Vol. IV. Comparison of the Vedic with the Later Representation of the Principal Indian Deities. Second Edition. 8vo, L1 1s.

Vol. V. Contributions to a Knowledge of the Cosmogony, Mythology, Religious Ideas, Life and Manners of the Indians in the Vedic Age. Third Edition. 8vo, L1 1s.

MÜLLER, F. Max.—Outline Dictionary, for the Use of Missionaries, Explorers, and Students of Language. 12mo, morocco, 7s. 6d.

The Sacred Hymns of the Brahmins, as preserved in the Oldest Collection of Religious Poetry, the Rig-Veda-Sancta. Translated by F. Max MÜLLER. Vol. I. Hymns to the Maruts, or the Storm-Gods. 8vo, 12s. 6d.


Nágánanda; or, The Joy of the Snake World. A Buddhist Drama. Translated from the Sanskrit of Sri-Harsha-Déva, with Notes. By P. BOYD. Crown 8vo, 4s. 6d.

NEWMAN, Francis William.—A Handbook of Modern Arabic. Post 8vo, 6s.


Oriental Text Society's Publications. A list may be had on application.

PALMER, the late E. H.—A Concise English-Persian Dictionary. With a Simplified Grammar of the Persian Language. Royal 16mo, 10s. 6d.


REDHOUSE, J. W.—The Turkish Vade-Mecum of Ottoman Colloquial Language. English and Turkish, and Turkish and English. The whole in English Characters, the Pronunciation being fully indicated. Third Edition. 32mo, 6s.
REDHOUSE, J. W.—continued.

On the History, System, and Varieties of Turkish Poetry. Illustrated by Selections in the Original and in English Paraphrase. 8vo, 2s. 6d.; wrapper, 1s. 6d.

A Tentative Chronological Synopsis of the History of Arabia and its Neighbours, from B.C. 500,000 (?) to A.D. 679. Demy 8vo, 1s.


SACHAU, Edward.—Albërûni's India. An Account of the Religion, Philosophy, Literature, Geography, Chronology, Astronomy, Customs, Laws, and Astrology of India, about A.D. 1030. Edited in the Arabic Original by Dr. EDWARD SACHAU. 4to, £3 3s.


SALMONÉ, H. A.—An Arabic-English Dictionary. Comprising about 120,000 Arabic Words, with an English Index of about 50,000 Words. 2 vols. Post 8vo, 36s.


SCOTT, James George.—Burma as it was, as it is, and as it will be. Cheap Edition. Crown 8vo, 2s. 6d.

SHERRING, M. A.—The Sacred City of the Hindus. An Account of Benares in Ancient and Modern Times. With Illustrations. 8vo, 21s.


SUYEMATZ, K.—Genji Monogatari. The Most Celebrated of the Classical Japanese Romances. Translated by K. SUYEMATZ. Crown 8vo, 7s. 6d.

TARRING, C. J.—A Practical Elementary Turkish Grammar. Crown 8vo, 6s.

Kegan Paul, Trench, Trübner & Co.'s Publications. 67

WATSON, John Forbes.—Index to the Native and Scientific Names of Indian and other Eastern Economic Plants and Products. Imperial 8vo, f 1 11s. 6d.


Early Records of British India. A History of the English Settlements in India, as told in the Government Records, and other Contemporary Documents, from the earliest period down to the rise of British Power in India. Royal 8vo, 15s.

WHITNEY, W. D.—A Sanskrit Grammar, including both the Classical Language and the older Dialects of Veda and Brahmana. Second Edition. 8vo, 12s.

WHITWORTH, George Clifford.—An Anglo-Indian Dictionary: a Glossary of Indian Terms used in English, and of such English or other Non-Indian Terms as have obtained special meanings in India. Demy 8vo, cloth, 12s.

WILLIAMS, S. Wells.—A Syllabic Dictionary of the Chinese Language; arranged according to the Wu-Fang Yuen Yin, with the Pronunciation of the Characters as heard in Pekin, Canton, Amoy, and Shanghai. 4to, £5 5s.

WILSON.—Works of the late Horace Hayman Wilson.


Vols. III., IV., and V. Essays Analytical, Critical, and Philological, on Subjects connected with Sanskrit Literature. Collected and Edited by Dr. REINHOLD ROST. 3 vols. Demy 8vo, 36s.

Vols. VI., VII., VIII., IX., and X. (2 parts). Vishnu Purána, a System of Hindu Mythology and Tradition. From the original Sanskrit. Illustrated by Notes derived chiefly from other Puránas, Edited by FITZEDWARD HALL, D.C.L. Vols. I. to V. (2 parts). Demy 8vo, £3 4s. 6d.


WRIGHT, W.—The Book of Kalilah and Dimnah. Translated from Arabic into Syriac. Demy 8vo, 21s.
TRUBNER'S ORIENTAL SERIES.


Texts from the Buddhist Canon, commonly known as Dhammapada. Translated from the Chinese by S. BEAL. 7s. 6d.

The History of Indian Literature. By ALBRECHT WEBER. Translated from the German by J. MANN and Dr. T. ZACHARIAE. Second Edition. 10s. 6d.

A Sketch of the Modern Languages of the East Indies. With 2 Language Maps. By ROBERT CUST. 7s. 6d.


Metrical Translations from Sanskrit Writers. By J. MUIR. 14s.


Selections from the Koran. By EDWARD WILLIAM LANE, A New Edition. With an Introduction by STANLEY LANE POOLE. 9s.


The Gulistan; or, Rose Garden of Shekh Mushliu-'d-Din Sadi of Shiraz. Translated from the Atish Kadah, by E. B. EASTWICK, F.R.S. Second Edition. 10s. 6d.

A Talmudic Miscellany; or, One Thousand and One Extracts from the Talmud, the Midrashim, and the Kabbalah. Compiled and Translated by P. J. HERSHON. 14s.

The History of Esarhaddon (Son of Sennacherib), King of Assyria, b.c. 681-668. Translated from the Cuneiform Inscriptions in the British Museum. Together with Original Texts. By E. A. BUDGE. 10s. 6d.

The Classical Poetry of the Japanese. By Basil Chamberlain. 7s. 6d.

Linguistic and Oriental Essays. By R. Cust, LL.D. First Series, 10s. 6d.; Second Series, with 6 Maps, 21s.


The Mesnevi (usually known as the Mesneviyi Sherīf, or Holy Mesnevi) of Mevlânā (Our Lord) Jelālu-d-Dīn Muhammed, Er-Rūmī. Book the First. Illustrated by a Selection of Characteristic Anecdotes as collected by their Historian Mevlânā Shemsu-d-Dīn Ahmed, El Efâkî El Arîfi. Translated by J. W. Redhouse. £1 1s.

Eastern Proverbs and Emblems illustrating Old Truths. By the Rev. J. Long. 6s.


The Quatrains of Omar Khayyām. The Persian Text, with an English Verse Translation. By E. H. Whinfield. 10s. 6d.

The Mind of Mencius; or, Political Economy founded upon Moral Philosophy. A Systematic Digest of the Doctrines of the Chinese Philosopher Mencius. The Original Text Classified and Translated by the Rev. E. Faber. Translated from the German, with Additional Notes, by the Rev. A. B. Hutchinson. 10s. 6d.

Yūsuf and Zulaïka. A Poem by Jami. Translated from the Persian into English Verse by R. T. H. Griffith. 8s. 6d.

Tsuni-|| Goam, the Supreme Being of the Khoi-Khoi. By Theophilus Hahn. 7s. 6d.

Hindu Philosophy: The Bhagavad Gîtâ; or, The Sacred Lay. A Sanskrit Philosophical Lay. Translated by John Davies. 8s. 6d.

The Sarva-Darsana-Samgraha; or, Review of the Different Systems of Hindu Philosophy. By Madhava Acharya. Translated by E. B. Cowell and A. E. Gough. 10s. 6d.

Tibetan Tales, Derived from Indian Sources. Translated from the Tibetan of the Kay-Gyur by F. Anton von Schieffner. Done into English from the German by W. R. S. Ralston. 14s.

Linguistic Essays. By Carl Abel. 9s.


History of the Egyptian Religion. By Dr. C. P. Tiele, Leiden. Translated by J. Ballingal. 7s. 6d.

The Philosophy of the Upanishads. By A. E. Gough. 9s.

Udanavarga. A Collection of Verses from the Buddhist Canon. Compiled by Dharmatrâta. Translated from the Tibetan by W. Woodville Rockhill. 9s.


Outlines of the History of Religion to the Spread of the Universal Religions. By Prof. C. P. Tiele. Translated from the Dutch by J. Estlin Carpenter. Fourth Edition. 7s. 6d.


The Ordinances of Manu. Translated from the Sanskrit. With an Introduction by the late A. C. Burnell, C.I.E. Edited by Edward W. Hopkins. 12s.

Ancient Proverbs and Maxims from Burmese Sources; or, The Niti Literature of Burma. By James Gray. 6s.

Manava-Dharma-Castra. The Code of Manu. Original Sanskrit Text, with Critical Notes. By Prof. J. Jolly, Ph.D. 10s. 6d.

Masnavi I Ma'navi. The Spiritual Couplets of Maulána Jalál-ud-Din Muhammad I Rúmi. Translated and Abridged. By E. H. Whinfield. 7s. 6d.

Leaves from my Chinese Scrap-Book. By F. H. Balfour. 7s. 6d.


Miscellaneous Essays on Subjects connected with the Malay Peninsula and the Indian Archipelago. From the "Journals" of the Royal Asiatic, Bengal Asiatic, and Royal Geographical Societies; the "Transactions" and "Journal" of the Asiatic Society of Batavia, and the "Malayan Miscellanies." Edited by R. Rost. Second Series. 2 vols. With 5 Plates and a Map. £1 5s.

The Satakas of Bhartrihari. Translated from the Sanskrit by the Rev. B. Hale Wortham. 5s.


The Folk-Tales of Kashmir. By the Rev. J. Hinton Knowles. 16s.

Mediaeval Researches from Eastern Asiatic Sources. Fragments towards the Knowledge of the Geography and History of Central and Western Asia from the Thirteenth to the Seventeenth Century. By E. Bretschneider, M.D. 2 vols. With 2 Maps. 21s.


Bihar Proverbs. By John Christian. [In preparation.]
A List of


---

MILITARY WORKS.


IV. The Elements of Military Administration. First Part: Permanent System of Administration. By Major J. W. Buxton. Small crown 8vo, 7s. 6d.


VI. Cavalry in Modern War. By Major-General F. Chenevix Trench, C.M.G. Small crown 8vo, 6s.

VII. Field Works. Their Technical Construction and Tactical Application. By the Editor, Col. C. B. Brackenbury, R.A. Small crown 8vo, in 2 parts, 12s.


COLVILLE, Lieut.-Col. C. F.—Military Tribunals. Sewed, 2s, 6d.
Kegan Paul, Trench, Trübner & Co.'s Publications. 73

CRAUFURD, Capt. H. J.—Suggestions for the Military Training of a Company of Infantry. Crown 8vo, 1s. 6d.

HAMILTON, Capt. Ian, A.D.C.—The Fighting of the Future. 1s.

HARRISON, Col. R.—The Officer’s Memorandum Book for Peace and War. Fourth Edition, Revised throughout. Oblong 32mo, red basil, with pencil, 3s. 6d.

Notes on Cavalry Tactics, Organisation, etc. By a Cavalry Officer. With Diagrams. Demy 8vo, 12s.

PARR, Col. H. Hallam, C.M.G.—The Dress, Horses, and Equipment of Infantry and Staff Officers. Crown 8vo, 1s.

Further Training and Equipment of Mounted Infantry. Crown 8vo, 1s.


STONE, Capt. F. Gleadowe, R.A.—Tactical Studies from the Franco-German War of 1870-71. With 22 Lithographic Sketches and Maps. Demy 8vo, 10s. 6d.

WILKINSON, H. Spenser, Capt. 20th Lancashire R.V.—Citizen Soldiers. Essays towards the Improvement of the Volunteer Force. Crown 8vo, 2s. 6d.

EDUCATIONAL.

ABEL, Carl, Ph.D.—Linguistic Essays. Post 8vo, 9s.

Slavic and Latin. Ilchester Lectures on Comparative Lexicography. Post 8vo, 5s.

ABRAHAMS, L. B.—A Manual of Scripture History for Use in Jewish Schools and Families. With Map and Appendices. Crown 8vo, 1s. 6d.

AHN, F.—A Concise Grammar of the Dutch Language, with Selections from the best Authors in Prose and Poetry. After Dr. F. Ahn’s Method. 12mo, 3s. 6d.

Practical Grammar of the German Language. Crown 8vo, 3s. 6d.
A List of

AHN, F.—continued.

New, Practical, and Easy Method of Learning the German Language. First and Second Courses in 1 vol. 12mo, 3s.

Key to Ditto. 12mo, 8d.

Manual of German and English Conversations, or Vade Mecum for English Travellers. 12mo, 1s. 6d.

New, Practical, and Easy Method of Learning the French Language. First Course and Second Course. 12mo, each 1s. 6d. The Two Courses in 1 vol. 12mo, 3s.

New, Practical, and Easy Method of Learning the French Language. Third Course, containing a French Reader, with Notes and Vocabulary. 12mo, 1s. 6d.

New, Practical, and Easy Method of Learning the Italian Language. First and Second Courses. 12mo, 3s. 6d.

Ahn’s Course. Latin Grammar for Beginners. By W. Ihne, Ph.D. 12mo, 3s.

BARANOWSKI, J. J.—Anglo-Polish Lexicon. Fcap. 8vo, 12s.

Slownik Polsko-Angielski. (Polish-English Lexicon.) Fcap. 8vo, 12s.

BELLOWS, John.—French and English Dictionary for the Pocket. Containing the French-English and English-French divisions on the same page; conjugating all the verbs; distinguishing the genders by different types; giving numerous aids to pronunciation; indicating the liaison or non-liaison of terminal consonants; and translating units of weight, measure, and value by a series of tables. Second Edition. 32mo, roan, 10s. 6d.; morocco tuck, 12s. 6d.

Tous les Verbes. Conjugations of all the Verbs in the French and English Languages. 32mo, 6d.

BOYESEN, Maria.—A Guide to the Danish Language. Designed for English Students. 12mo, 5s.

BOLIA, C.—The German Caligraphist. Copies for German Hand-writing. Oblong 4to, 1s.

BOWEN, H. C., M.A.—Studies in English. For the use of Modern Schools. Tenth Thousand. Small crown 8vo, 1s. 6d.

English Grammar for Beginners. Fcap. 8vo, 1s.

Simple English Poems. English Literature for Junior Classes. In four parts. Parts I., II., and III., 6d. each. Part IV., 1s. Complete, 3s.

French Examination Papers set at the University of London. Key to Part I. Edited by the Rev. P. H. E. BRETTE and F. THOMAS. Crown 8vo, 5s.

French Examination Papers set at the University of London. Part II. Crown 8vo, 7s.

BUTLER, F.—The Spanish Teacher and Colloquial Phrase Book. 12mo, half-roan, 2s. 6d.

BYRNE, James.—General Principles of the Structure of Language. 2 vols. Demy 8vo, 36s.

The Origin of Greek, Latin, and Gothic Roots. Demy 8vo, 18s.

CAMERINI, E.—L'Eco Italiano. A Practical Guide to Italian Conversation. With a Vocabulary. 12mo, 4s. 6d.


CONWAY, R. Seymour.—Verner's Law in Italy. An Essay in the History of the Indo-European Sibilants. Demy 8vo, 5s.

The Italic Dialects. I. The Text of the Inscriptions. II. An Italic Lexicon. Edited and arranged by R. SEYMOUR CONWAY. 8vo. [In preparation.

DELBRÜCK, B.—Introduction to the Study of Language. The History and Methods of Comparative Philology of the Indo-European Languages. 8vo, 5s.


A Grammatical Course of the German Language. Third Edition. Crown 8vo, 3s. 6d.

Education Library. Edited by Sir PHILIP MAGNUS:

An Introduction to the History of Educational Theories. By OSCAR BROWNING, M.A. Second Edition. 3s. 6d.
Education Library—continued.

Industrial Education. By Sir Philip Magnus. 6s.

Old Greek Education. By the Rev. Prof. Mahaffy, M.A. Second Edition. 3s. 6d.


Eger, Gustav.—Technological Dictionary in the English and German Languages. Edited by Gustav Eger. 2 vols. Royal 8vo, £1 7s.

Ellis, Robert.—Sources of the Etruscan and Basque Languages. Second Edition. 3 a 6d.

Eger, Gustav.—Technological Dictionary in the English and German Languages. Edited by Gustav Eger. 2 vols. Royal 8vo, £1 7s.

Ellis, Robert.—Sources of the Etruscan and Basque Languages. Second Edition. 3 a 6d.

Friedrich, P.—Progressive German Reader. With Copious Notes to the First Part. Crown 8vo, 4s. 6d.

Fröembling, Friedrich Otto.—Graduated German Reader. A Selection from the most Popular Writers; with a Vocabulary for the First Part. Tenth Edition. 12mo, 3s. 6d.

Graduated Exercises for Translation into German. Consisting of Extracts from the best English Authors; with Idiomatic Notes. Crown 8vo, 4s. 6d. Without Notes, 4s.


Geldart, E. M.—A Guide to Modern Greek. Post 8vo, 7s. 6d. Key, 2s. 6d.


Hodgson, W. B.—The Education of Girls; and the Employment of Women of the Upper Classes Educationally considered. Second Edition. Crown 8vo, 3s. 6d.


Lange, F. K. W.—Germania. A German Reading-Book Arranged Progressively. Part I. Anthology of German Prose and Poetry, with Vocabulary and Biographical Notes. 8vo, 3s. 6d. Part II. Essays on German History and Institutions, with Notes. 8vo, 3s. 6d. Parts I. and II. together, 5s. 6d.
LANGE, F. K. W.—continued.
German Grammar Practice. Crown 8vo, 1s. 6d.
Colloquial German Grammar. Crown 8vo, 4s. 6d.

LE-BRUN, L.—Materials for Translating from English into French. Seventh Edition. Post 8vo, 4s. 6d.


MAGNUS, Sir Philip.—Industrial Education. Crown 8vo, 6s.

MASON, Charlotte M.—Home Education; a Course of Lectures to Ladies. Crown 8vo, 3s. 6d.

MILLHOUSE, John.—Pronouncing and Explanatory English and Italian Dictionary. 2 vols. 8vo, 12s.

Manual of Italian Conversation. 18mo, 2s.

Modern French Reader (The). A Glossary of Idioms, Gallicisms, and other Difficulties contained in the Senior Course of the Modern French Reader. By CHARLES CASSAL. Crown 8vo, 2s. 6d.


Modern French Reader. Senior Course and Glossary combined. 6s.

NUGENT.—Improved French and English and English and French Pocket Dictionary. 24mo, 3s.

OLLENDORFF.—Metodo para aprender a Leer, escribir y hablar el Inglés segun el sistema de Ollendorff. Por RAMON PALENZUELA y JUAN DE LA CARREÑO. 8vo, 4s. 6d. Key to ditto. Crown 8vo, 3s.

Metodo para aprender a Leer, escribir y hablar el Frances, segun el verdadero sistema de Ollendorff. Por TEODORO SIMONNE. Crown 8vo, 6s. Key to ditto. Crown 8vo, 3s. 6d.


L'Honneur et l'Argent. A Comedy. Edited, with English Notes and Memoir of Ponsard, by Professor C. CASSAL, LL.D. Second Edition. 12mo, 3s. 6d.

RASK, Erasmus.—Grammar of the Anglo-Saxon Tongue, from the Danish of ERASMUS RASK. By BENJAMIN THORPE. Third Edition. Post 8vo, 5s. 6d.

A Graduated Russian Reader. With a Vocabulary. Crown 8vo, 10s. 6d.

ROCHE, A.—A French Grammar. Adopted for the Public Schools by the Imperial Council of Public Instruction. Crown 8vo, 3s.
Prose and Poetry. Select Pieces from the best English Authors, for Reading, Composition, and Translation. Second Edition. Fcap. 8vo, 2s. 6d.

ROSING, S.—English-Danish Dictionary. Crown 8vo, 8s. 6d.

SAYCE, A. H.—An Assyrian Grammar for Comparative Purposes. Crown 8vo, 7s. 6d.
The Principles of Comparative Philology. Third Edition. Crown 8vo, 10s. 6d.

SINCLAIR, F.—A German Vocabulary. Crown 8vo, 2s.


TOSCANI, Giovanni.—Italian Conversational Course. Fourth Edition. 12mo, 5s.
Italian Reading Course. Fcap. 8vo, 4s. 6d.

Trübner's Catalogue of Dictionaries and Grammars of the Principal Languages and Dialects of the World. Second Edition. 8vo, 5s.

Trübner's Collection of Simplified Grammars of the Principal Asiatic and European Languages. Edited by REINHOLD ROST, LL.D. Crown 8vo.
II. Hungarian. By I. SINGER. 4s. 6d.
III. Basque. By W. VAN EYS. 3s. 6d.
IV. Malagasy. By G. W. PARKER. 5s.
V. Modern Greek. By E. M. GELDART. 2s. 6d.
VI. Roumanian. By R. TORCEANU. 5s.
VII. Tibetan Grammar. By H. A. JASCHKE. 5s.
VIII. Danish. By E. C. OTTÉ. 2s. 6d.
IX. Turkish. By J. W. REDHOUSE. 10s. 6d.
Trübner’s Collection of Simplified Grammars of the Principal Asiatic and European Languages—continued.

X. Swedish. By E. C. Otté. 25. 6d.

XI. Polish. By W. R. Morfill. 35. 6d.

XII. Pali. By E. Müller. 75. 6d.

XIII. Sanskrit. By H. Edgren. 105. 6d.

XIV. Grammaire Albanaise. Par P. W. 75. 6d.


XVI. Serbian. By W. R. Morfill. 45. 6d.

XVII. Cuneiform Inscriptions. By George Bertin, 55.

XVIII. Panjábi Language. By the Rev. W. St. Clair Tisdall. 75. 6d.

XIX. Spanish. By W. F. Harvey. 35. 6d.


VELASQUEZ, M., de la Cadena.—A Dictionary of the Spanish and English Languages. For the Use of Young Learners and Travellers. In 2 parts. I. Spanish-English. II. English-Spanish. Crown 8vo, 6s.

A Pronouncing Dictionary of the Spanish and English Languages. 2 parts in one volume. Royal 8vo, £1 4s.

New Spanish Reader. Passages from the most approved Authors, in Prose and Verse. With Vocabulary. Post 8vo, 6s.

An Easy Introduction to Spanish Conversation. 12mo, 2s. 6d.

VELASQUEZ and SIMONNÉ.—New Method to Read, Write, and Speak the Spanish Language. Adapted to Ollendorff’s System. Post 8vo, 6s. Key. Post 8vo, 4s.


WELLER, E.—An Improved Dictionary. English and French, and French and English. Royal 8vo, 75. 6d.


A List of

WHITNEY, Prof. William Dwight.—Essentials of English Grammar, for the Use of Schools. Second Edition. Crown 8vo, 3s. 6d.


POETRY.

ADAMS, Estelle Davenport.—Sea Song and River Rhyme, from Chaucer to Tennyson. With 12 Etchings. Large crown 8vo, 10s. 6d.


ARNOLD, Sir Edwin, C.S.I.—In my Lady's Praise. Being Poems Old and New, written to the Honour of Fanny, Lady Arnold. Imperial 16mo, parchment, 3s. 6d.


* * * See also under ORIENTAL.

BADDELEY, St. Clair.—Lotus Leaves. Fcap. folio, boards, 8s. 6d.


BLUNT, Wilfrid Seavon.—The Wind and the Whirlwind. Demy 8vo, 1s. 6d.


In Vinculis. With Portrait. Elzevir 8vo, 5s.

A New Pilgrimage, and other Poems. Elzevir 8vo, 5s.

BRYANT, W. C.—Poems. Cheap Edition, with Frontispiece. Small crown 8vo, 3s. 6d.

CODD, John.—A Legend of the Middle Ages, and other Songs of the Past and Present. Crown 8vo, 4s.

DASH, Blancor.—Tales of a Tennis Party. Small crown 8vo, 5s.

DAWE, William.—Sketches in Verse. Small crown 8vo, 3s. 6d.

DAWSON, C. A.—Sappho. Small crown 8vo, 5s.
DE VERE, Aubrey.—Poetical Works.
   I. THE SEARCH AFTER PROSERPINE, etc. 3s. 6d.
   II. THE LEGENDS OF ST. PATRICK, etc. 3s. 6d.
   III. ALEXANDER THE GREAT, etc. 3s. 6d.

The Foray of Queen Meave, and other Legends of Ireland's
Heroic Age. Small crown 8vo, 3s. 6d.

Legends of the Saxon Saints. Small crown 8vo, 3s. 6d.

Legends and Records of the Church and the Empire.
Small crown 8vo, 3s. 6d.

DOBSON, Austin.—Old World Idylls, and other Verses. Elzevir
8vo, gilt top, 6s.

At the Sign of the Lyre. Elzevir 8vo, gilt top, 6s.

DOYLE, J.—Cause. Small crown 8vo, 6s.

DURANT, Hildegarde.—Dante. A Dramatic Poem. Small crown 8vo, 5s.

DUTT, Toru.—A Sheaf Gleaned in French Fields. Demy 8vo, 10s. 6d.

Ancient Ballads and Legends of Hindustan. With an
Introductory Memoir by EDMUND GOSSE. 18mo. Cloth extra,
gilt top, 5s.

Elegies and Memorials. By A. and L. Fcap. 8vo, 2s. 6d.

ELLIOIT, Ebenezer, The Corn Law Rhymer.—Poems. Edited by his
son, the Rev. EDWIN ELLIOTT, of St. John's, Antigua. 2 vols.
Crown 8vo, 18s.

English Verse. Edited by W. J. LINTON and R. H. STODDARD.
5 vols. Crown 8vo, cloth, 5s. each.
   I. CHAUCER TO BURNS.
   II. TRANSLATIONS.
   III. LYRICS OF THE NINETEENTH CENTURY.
   IV. DRAMATIC SCENES AND CHARACTERS.
   V. BALLADS AND ROMANCES.

FIFE-COOKSON, Lieut.-Col.—The Empire of Man. Small crown
8vo, 2s. 6d.

GARRICK, H. B. W.—India. A Descriptive Poem. Crown 8vo,
7s. 6d.

GOSSE, Edmund.—New Poems. Crown 8vo, 7s. 6d.

8vo, gilt top, 6s.

On Viol and Flute; Lyrical Poems. With Frontispiece by L.
ALMA TADEMA, R.A., and Tailpiece by HAMO THORNYCROFT,
R.A. Elzevir 8vo, 6s.
GRAY, Maxwell.—Westminster Chimes, and other Poems. Small crown 8vo, 5s.

GURNEY, Rev. Alfred.—The Vision of the Eucharist, and other Poems. Crown 8vo, 5s.

A Christmas Faggot. Small crown 8vo, 5s.

Voices from the Holy Sepulchre. Crown 8vo, 5s.


HEINE, Heinrich.—The Love-Songs of. Englished by H. B. Briggs. Post 8vo, parchment, 3s. 6d.

HUES, Ivan.—Heart to Heart. Small crown 8vo, 5s.

INGLEBY, Holcombe.—Echoes from Naples, and Other Poems. With Illustrations by his Wife. Crown 8vo, 3s. 6d.


The Sermon in the Hospital (from "The Disciples"). Fcap. 8vo, 1s. Cheap Edition for distribution 3d., or 20s. per 100.

Ballads of the North, and other Poems. Crown 8vo, 5s.

LANG, A.—XXXII. Ballades in Blue China. Elzevir 8vo, 5s.


LULWORTH, Eric.—Sunshine and Shower, and other Poems. Small crown 8vo, 5s.

LYALL, Sir Alfred.—Verses written in India. Elzevir 8vo, gilt top, 5s.

MASSEY, Gerald.—My Lyricial Life. Poems Old and New. Two Series. Fcap. 8vo, 5s. each.

MEREDITH, Owen [The Earl of Lytton].—Lucile. New Edition. With 32 Illustrations. 16mo, 3s. 6d. Cloth extra, gilt edges, 4s. 6d.


The Epic of Hades. With 16 Autotype Illustrations, after the Drawings of the late George R. Chapman. 4to, cloth extra, gilt leaves, 21s.

The Epic of Hades. Presentation Edition. 4to, cloth extra, gilt leaves, 10s. 6d.

The Lewis Morris Birthday Book. Edited by S. S. Cope-
man, with Frontispiece after a Design by the late George R. Chapman. 32mo, cloth extra, gilt edges, 2s.; cloth limp, 1s. 6d.

OWEN, John.—Verse Musings on Nature. Faith and Freedom. Crown 8vo, 7s. 6d.

PFEIFFER, Emily.—Flowers of the Night. Crown 8vo, 6s.

PIERCE, J.—In Cloud and Sunshine. A Volume of Poems. Fcap. 8vo, 5s.

POE, Edgar Allan.—The Raven. With Commentary by JOHN II.
INGRAM. Crown 8vo, parchment, 6s.

Rare Poems of the 16th and 17th Centuries. Edited by W. J.
LINTON. Crown 8vo, 5s.

ROWBOTHAM, J. F.—The Human Epic. Canto i. Crown 8vo, 1s. 6d.

KUNEBERG, Johan Ludvig.—Nadeschda. A Romantic Poem in Nine Cantos. Translated from the Swedish by Miss MARIE A.
BROWN (MRS. JOHN B. SHIPLEY). With Illustrations. 8vo. [In preparation.

SCOTT, G. F. E.—Sursum Corda; or, Songs and Service. Small
. crown 8vo, 5s.

SEARELLE, Luscombe.—The Dawn of Death. Crown 8vo, 4s. 6d.

SYMONDS, John Addington.—Vagabunduli Libellus. Crown 8vo, 6s.


Philip Van Artevelde. Fcap. 8vo, 3s. 6d.

The Virgin Widow, etc. Fcap. 8vo, 3s. 6d.
A List of

TRENCH, Archbishop.—Poems. Collected and Arranged anew. Tenth Edition. Fcap. 8vo, 7s. 6d.


TYNAN, Katherine.—Louise de la Valliere, and other Poems. Small crown 8vo, 3s. 6d.

Shamrocks. Small crown 8vo, 5s.

WADDIE, John.—Divine Philosophy. Small crown 8vo, 5s.

WILSON, Crawford.—Pastorals and Poems. Crown 8vo, 7s. 6d.

Wordsworth Birthday Book (The). Edited by Adelaide and Violet Wordsworth. 32mo, limp cloth, 15s. 6d.; cloth extra, 25s.


YEATS, W. B.—The Wanderings of Oisin, and other Poems. Small crown 8vo, 5s.

NOVELS AND TALES.

BANKS, Mrs. G. L.—God's Providence House. Crown 8vo, 6s.

BILLER, Emma.—Ulli. The Story of a Neglected Girl. Translated from the German by A. B. DAISY ROST. Crown 8vo, 6s.

CABLE, G. W.—Strange True Stories of Louisiana. 8vo, 7s. 6d.

CAIRD, Mona.—The Wing of Azrael. Crown 8vo, 6s.


CRAWFURD, Oswald.—Sylvia Arden. With Frontispiece. Crown 8vo, 1s.


EBERS, Georg.—Margery. A Tale of Old Nuremberg. Translated from the German by CLARA BELL. 2 vols. 8s.; paper, 5s.
ECKSTEIN, Ernst.—Nero. A Romance. Translated from the German by CLARA BELL and MARY J. SAFFORD. 2 vols. Paper, 5s.

FLETCHER, J. S.—Andrewwina. Crown 8vo, cloth, 1s. 6d.; paper covers, 1s.


FRANCIS, Frances.—Mosquito. A Tale of the Mexican Frontier. Crown 8vo, 3s. 6d.

Galdos, B. Perez.—Leon Roche. A Romance. From the Spanish by CLARA BELL. 2 vols. 16mo, cloth, 8s.; paper, 5s.

GARDINER, Linda.—His Heritage. With Frontispiece. Crown 8vo, 6s.

GRAY, Maxwell.—The Reproach of Annesley. With Frontispiece. Crown 8vo, 6s.

Silence of Dean Maitland. With Frontispiece. Crown 8vo, 6s.


Lindenblumen and other Stories. Small crown 8vo, 5s.

By Virtue of his Office. Crown 8vo, 6s.

Jacob's Letter, and other Stories. Crown 8vo, 6s.

HARRIS, Emily Marion.—Lady Dobbs. A Novel. In 2 vols. 21s.


INGELOW, Jean.—Off the Skelligs. A Novel. With Frontispiece. Crown 8vo, 6s.

LANG, Andrew.—In the Wrong Paradise, and other Stories. Crown 8vo, 6s.


Home Again. With Frontispiece. Crown 8vo, 6s.


Malcolm. With Portrait of the Author engraved on Steel. Crown 8vo, 6s.

The Marquis of Lossie. With Frontispiece. Crown 8vo, 6s.

St. George and St. Michael. With Frontispiece. Crown 8vo, 6s.


MACDONALD, G.—continued.


Thomas Wingfold, Curate. With Frontispiece. Crown 8vo, 6s.

Paul Faber, Surgeon. With Frontispiece. Crown 8vo, 6s.

The Elect Lady. With Frontispiece. Crown 8vo, 6s.


A Counsel of Perfection. With Frontispiece. Crown 8vo, 6s.

MULHOLLAND, Rosa.—Marcella Grace: An Irish Novel. Crown 8vo, 6s.

A Fair Emigrant. With Frontispiece. Crown 8vo, 6s.

OGLE, Anna C.—A Lost Love. Small crown 8vo, 2s. 6d.

PONTOPIDDAN, Henrik.—The Apothecary’s Daughters. Translated from the Danish by Gordius Nielsen. Crown 8vo, 3s. 6d.

ROBINSON, Sir J. C.—The Dead Sailor, and other Stories. Crown 8vo, 5s.

SAVILE, Ames.—A Match Pair. 2 vols. 21s.

SEVERNE, Florence.—The Pillar House. With Frontispiece. Crown 8vo, 6s.

SHAW, Flora L.—Castle Blair: a Story of Youthful Days. Crown 8vo, 3s. 6d.


TASMA.—A Sydney Sovereign, and other Tales. Crown 8vo, cloth, 6s.


In her Earliest Youth. 3 vols. Crown 8vo, 31s. 6d.


Ralph Darnell. With Frontispiece. Crown 8vo, 6s.

A Noble Queen. With Frontispiece. Crown 8vo, 6s.


TOORGEYNIEFF, Ivan.—The Unfortunate One. A Novel. Translated from the Russian by A. R. THOMPSON. Crown 8vo, 3s. 6d.

TREHERNE, Mrs.—A Summer in a Dutch Country House. Crown 8vo, 6s.

Within Sound of the Sea. With Frontispiece. Crown 8vo, 6s.

BOOKS FOR THE YOUNG.

Brave Men’s Footsteps. A Book of Example and Anecdote for Young People. By the Editor of “Men who have Risen.” With 4 Illustrations by C. DOYLE. Ninth Edition. Crown 8vo, 2s. 6d.

COXHEAD, Ethel.—Birds and Babies. With 33 Illustrations. Second Edition. Imp. 16mo, cloth, 1s.


MALET, Lucas.—Little Peter. A Christmas Morality for Children of any Age. With numerous Illustrations. Fourth Thousand. 5s.

REANEY, Mrs. G. S.—Waking and Working; or, From Girlhood to Womanhood. New and Cheaper Edition. With a Frontispiece. Crown 8vo, 3s. 6d.


Rose Gurney’s Discovery. A Story for Girls. Dedicated to their Mothers. Crown 8vo, 3s. 6d.


Just Anyone, and other Stories. Three Illustrations. Royal 16mo, 1s. 6d.

Sunbeam Willie, and other Stories. Three Illustrations. Royal 16mo, 1s. 6d.

Sunshine Jenny, and other Stories. Three Illustrations. Royal 16mo, 1s. 6d.

STORR, Francis, and TURNER, Hawes.—Canterbury Chimes; or, Chaucer Tales re-told to Children. With 6 Illustrations from the Ellesmere Manuscript. Third Edition. Fcap. 8vo, 3s. 6d.
A List of

STRETTON, Hesba.—David Lloyd's Last Will. With 4 Illustrations. New Edition. Royal 16mo, 2s. 6d.

WHITAKER, Florence.—Christy's Inheritance. A London Story. Illustrated. Royal 16mo, 1s. 6d.

PERIODICALS.

Amateur Mechanical Society's Journal.—Irregular.

Anthropological Institute of Great Britain and Ireland (Journal of).—Quarterly, 5s.

Architect (American) and Building News.—Contains General Architectural News, Articles on Interior Decoration, Sanitary Engineering, Construction, Building Materials, etc. 4 full-page Illustrations accompany each Number. Weekly. Annual Subscription, 38s. Post free.

Bibliotheca Sacra.—Quarterly, 3s. 6d. Annual Subscription, 14s. Post free.

British Archæological Association (Journal of).—Quarterly, 8s.

British Chess Magazine.—Monthly, 8d.

British Homœopathic Society (Annals of).—Half-yearly, 2s. 6d.

Browning Society's Papers.—Irregular.

Calcutta Review.—Quarterly, 6s. Annual Subscription, 24s. Post free.

Cambridge Philological Society (Proceedings of).—Irregular.

Englishwoman's Review. — Social and Industrial Questions. Monthly, 6d.

Geological Magazine, or Monthly Journal of Geology, 1s. 6d. Annual Subscription, 18s. Post free.

Index Medicus.—A Monthly Classified Record of the Current Medical Literature of the World. Annual Subscription, 50s. Post free.


Indian Evangelical Review.—Annual Subscription, 10s.

Indian Magazine. Monthly, 6d.

Library Journal.—Official Organ of the Library Associations of America and of the United Kingdom. Monthly, 2s. 6d. Annual Subscription, 20s., or with Co-operative Index, 25s. Post free.
Mathematics (American Journal of).—Quarterly, 7s. 6d. Annual Subscription, 24s. Post free.
Meister (The).—Journal of the Wagner Society. 4to, 1s.
Nineteenth Century.—Monthly, 2s. 6d.
Orientalist (The).—Monthly. Annual Subscription, 12s.
Orthodox Catholic Review.—Irregular.
Philological Society (Transactions and Proceedings of).—Irregular.
Psychical Research (Society of), Proceedings of.
Punjab Notes and Queries.—Monthly. Annual Subscription, 10s.
Revue Internationale.—Issued on the 10th and 25th of each Month. Annual Subscription, including postage, 36s.
Scientific American.—Weekly. Annual Subscription, 18s. Post free.
Supplement to ditto.—Weekly. Annual Subscription, 25s. Post free.
Science and Arts (American Journal of).—Monthly, 2s. 6d. Annual Subscription, 30s.
Speculative Philosophy (Journal of).—Quarterly, 4s. Annual Subscription, 16s. Post free, 17s.
Sun Artists.—Quarterly, 5s.
Sunday Review.—Organ of the Sunday Society for Opening Museums and Art Galleries on Sunday. Quarterly, 1s. Annual Subscription, 4s. 6d. Post free.
Theosaphist (The).—Magazine of Oriental Philosophy, Art, Literature, and Occultism. Monthly, 2s.
Trübner's Record.—A Journal devoted to the Literature of the East, with Notes and Lists of Current American, European, and Colonial Publications. Small 4to, 2s. per number. Annual Subscription, 10s. Post free.
SHAKSPERE'S WORKS.

THE AVON EDITION.

Printed on thin opaque paper, and forming 12 handy volumes, cloth, 18s., or bound in 6 volumes, 15s.

The set of 12 volumes may also be had in a cloth box, price 21s., or bound in Roan, Persian, Crushed Persian Levant, Calf, or Morocco, and enclosed in an attractive leather box at prices from 31s. 6d. upwards.

SOME PRESS NOTICES.

"This edition will be useful to those who want a good text, well and clearly printed, in convenient little volumes that will slip easily into an overcoat pocket or a travelling-bag."—St. James's Gazette.

"We know no prettier edition of Shakspere for the price."—Academy.

"It is refreshing to meet with an edition of Shakspere of convenient size and low price, without either notes or introductions of any sort to distract the attention of the reader."—Saturday Review.

"It is exquisite. Each volume is handy, is beautifully printed, and in every way lends itself to the taste of the cultivated student of Shakspere."—Scotsman.

LONDON: KEGAN PAUL, TRENCH, TRÜBNER & CO., LTd.
SHAKSPERE'S WORKS.

THE PARCHMENT LIBRARY EDITION.

In 12 volumes Elzevir 8vo., choicely printed on hand-made paper, and bound in parchment or cloth, price £3 12s., or in vellum, price £4 10s.

The set of 12 volumes may also be had in a strong cloth box, price £3 17s., or with an oak hanging shelf, £3 18s.

SOME PRESS NOTICES.

“... There is, perhaps, no edition in which the works of Shakspere can be read in such luxury of type and quiet distinction of form as this, and we warmly recommend it.”—Pall Mall Gazette.

“For elegance of form and beauty of typography, no edition of Shakspere hitherto published has excelled the 'Parchment Library Edition.' ... They are in the strictest sense pocket volumes, yet the type is bold, and, being on fine white hand-made paper, can hardly tax the weakest of sight. The print is judiciously confined to the text, notes being more appropriate to library editions. The whole will be comprised in the cream-coloured parchment which gives the name to the series.”—Daily News.

“The Parchment Library Edition of Shakspere needs no further praise.”—Saturday Review.

Just published. Price 5s.

AN INDEX TO THE WORKS OF SHAKSPERE.

Applicable to all editions of Shakspere, and giving reference, by topics, to notable passages and significant expressions; brief histories of the plays; geographical names and historic incidents; mention of all characters and sketches of important ones; together with explanations of allusions and obscure and obsolete words and phrases.

By EVANGELINE M. O'CONNOR.

London: Kegan Paul, Trench, Trübner & Co., Lt?