BIRMINGHAM NATURAL HISTORY

AND

MICROSCOPICAL SOCIETY.

REPORT & TRANSACTIONS

FOR

THE YEAR 1880.

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CONTENTS

TRANSACTIONS.

An arrangement having been made with the Editors of the "Midland Naturalist" to reprint for the Society at the end of each year the papers read before it, which have appeared in the Magazine, the Committee are enabled to issue on the present occasion a not unsatisfactory record of the Society's transactions during the past twelve months.

Mason's College, April, 1881.

ADDRESS OF THE PRESIDENT,

WILLIAM SOUTHALL, ESQ., F.L.S.

DELIVERED AT THE ADJOURNED ANNUAL MEETING, APRIL 5, 1881.

MR. PRESIDENT, LADIES, AND GENTLEMEN—

At the commencement of the present session I had the honour to address the Society on taking possession of its new quarters in this noble building. The prospective advantages which I foreshadowed as awaiting us have been amply realised, and I have now only to congratulate our members upon our established position in rooms so excellent and suitable for the purposes of the Society, which the enlightened liberality of the Council of Mason's College has enabled us to occupy.

I propose this evening to address you upon the subject of Botany in general, entering a little into its history, and a little into some of its more recent developments, hoping thereby, although I may not follow a strictly scientific path, to interest some who have not hitherto made a study of the second great Kingdom of Organic Life.

All the world is fond of flowers ; the factory girl of the smoky town, who mostly has to content herself with artificial substitutes, equally with the Hawaiian* beauty, who, with exquisite grace, garlands herself with wreaths of the splendid Hibiscus ; the shoemaker, or the grimy smith, who, on his little suburban patch, grows auriculas or carnations for show, equally with the well-got-up gentleman, who goes down to the House of Commons with a bouquet of exotics sent up from his place in the country in his button-hole.

The attractions of the woods and the fields depend wholly upon the beauties of the vegetable world, ever present, but changing with the changing seasons, whether in the outburst of

* See "The Earl and the Doctor."

delicious green, the blaze of flowers, or the teeming wealth of fruits ; even decay itself brings forth its special charms. The loftiest trees and the lowliest plants—witness the cushions of brilliant green moss or the splash of lichen upon the rock—each have their place, and combine to make up the perfect whole.

Most people profess an admiration of the floral aspect of Nature ; with many the admiration is most genuine, and yet with all these attractions there are comparatively few Botanists —few who care to study the history, the life, the relationships of plants, which constitute the science of Botany.

Why should this be ? In this room we are most of us Naturalists—how did we become so ? The schoolboy, if he be at school in the country, and has a taste for Natural History, is very apt, if he be of the ordinary type, to prefer any branch which involves killing something, or, at all events, stealing, as collecting eggs—hereditary instinct you will say ; but if he have a real liking for Natural History, he will probably keep pet toads or snakes in his desk or pockets, and will acquire a most particular knowledge of the habits and nature of his little friends, and thus begin a practical acquaintance with Zoology ; or he may be an Entomologist, and besides collecting, keep a farm for his caterpillars and larvæ. The Botanist is more rare ; the attractions that draw him have not power over the many, but those who do take up the study are often apt learners, and do honour to schoolboy science, acquired in schoolboy age.

Botany as Natural History, and Botany as a science have rather a different look. Of course we know that now-a-days science of all kinds is taught in schools, and doubtless very well taught, but it is not schoolboy science ; and whether those who commence their studies under the blue heavens, or under teachers and the voice of professors lay the best foundation, I have not to judge. I have only to say that those who begin the study of nature in the class-room miss a very pleasant experience. Nor must I omit the ladies. From what we have heard of ladies' schools formerly, nothing would seem more foreign to their teaching than Physiology, animal or vegetable, but ladies seem now likely to leave the stronger sex behind even in these subjects. This, however, is merely a suggestion.

To many minds there is something forbidding in the very aspect and idea of science of whatever kind. Scientific knowledge is supposed to be something inherently different from common knowledge, a knowledge for which ordinary sense and observation will not suffice. On the contrary common sense is most necessary for the unprejudiced observation of the phenomena of Nature. The carrying out of an investigation may require patience and skill, but not any recondite power unavailable to the ordinary intellect. Moreover, whilst science as such has a forbidding aspect, there is no doubt that a great scientific wave has rolled over modern thought and speculation. Never had scientific discoveries a greater interest for the bulk of thinking people than at present. Metaphysics have lost their popularity—somewhat limited as far as England was concerned—and the culture of the age no longer talks of pure reason, but of the potentiality of matter, evolution, protoplasm, life and organisation. The study of Botany may seem a very long way from these high things, but how can a man talk, not to say think about them, unless he knows something of the facts upon which modern speculations are founded. Animal life is the great arcanum, but it cannot be separated from vegetable life, side by side of which it lives in its lower forms, and without which it cannot exist.

The terminology of Botany is a stumbling block to many. It is the tendency especially of our Teutonic friends to multiply terms that are unattractive and uncouth. For instance, I noticed the following announcement:—"Dr. Eriksson has recently discovered at Leipzig the protomeristem in the roots of Dicotyledons. It appears that the root apex consists of three zones of meristem, the pleroma, the periblem, and the dermocalyptrogen," and so on. Pretty well, this, for the point of a root, but I hope to show that a great portion of the most interesting features of Botany may be studied with very little requirement of the use of scientific terms.

Mr. Ruskin has recently announced himself a botanical teacher. He complains that the scientific names of plants are too numerous, therefore he proposes to abolish them and give new ones. He also complains that the current English names of plants are, many of them, of the Devil's own contriving, founded on some unclean or debasing association. His new names are pretty, but will, probably, never get beyond the volume that contains them; but this volume, like others of his works, contains exquisite descriptions of plants; and if some parts of "Proserpina" are very wild, you will also find, if not science, much that will attract you to Botany, and the derivation of many common botanical terms most happily given. Botanical writers are soundly rated, but that is what may be expected.

At what period in the world's history does Botany begin? Pray do not be frightened—I must conclude some time—if I suggest that a practical knowledge of plants, which we may call applied Botany, began at a very early age, in fact earlier than any written history. In the earliest written records preserved to us man is described as already a tiller of the ground, therefore a grower of cereals, a bread-eater, or, at all events, a cooker of food. He also used the fibres of plants for the manufacture of textile fabrics. These facts indicate a large advance in the arts of civilisation from the conditions that the advocates of the view of the antiquity of man would ascribe to him in his primeval state. He was originally a frugivorous animal, and over large parts of the district commonly supposed to have been the cradle of the human race, the date-palm yields a nourishing fruit that may be obtained without much difficulty or care. Other fruits, as the fig, also flourish; these, therefore, may have been his earliest selection.

The science of the Greeks originated about 600 B.C. In its earliest periods botanical notices occur. Hippocrates of Cos, the physician, was acquainted with many plants still in use in medicine. Spices and gums were early prized. Xenophon of Colophanes was acquainted with the true nature of fossil plants and animals—a knowledge which lapsed for many ages. Herodotus gives occasional information in Natural History. On his visit to Egypt, about 400 B.C., he says he was shewn an inscription on the Pyramid of Cheops, built some 3,000 years before, which gave the value of the garlic, onions, and radishes consumed by the labourers whilst building it—namely, one thousand six hundred talents of silver. He does not mention the salt, however, with which the whole should be taken. From his own observation, he informs us that the lotus, the fruit of which is contained in a pod like a wasp's nest, in which are berries fit to be eaten—the *Nelumbium*—and another lotus are used for food; the roots also being eaten. The byblus is an annual plant, the upper parts being used for various purposes, and the lower part of the stem eaten—the Egyptians cooking it delicately.

Aristotle is the first to notice plants from a biological point of view. In his "History of Animals" he says: "The whole genus of plants, however, compared with the other bodies, appears to be nearly, as it were, animated, but, when compared with an animal, to be inanimate. But the transition from plants to animals is, as we have before observed, continued. For, with respect to some of the bodies in the sea, it may be doubted whether they are plants or animals." In a March periodical of this year the writer of the scientific article says: "It seems but yesterday when we regarded the sponge as a vegetable product," and yet two thousand years ago Aristotle classed it among animals, though, as might be expected, he had not a very clear notion of its structure.

Theophrastus, the pupil of Aristotle, is usually regarded as the first Botanist. He abandoned the transcendental element in his master's teaching and taught "positive" science. He classed plants as herbs, trees, and shrubs, and wrote, as a seventeenth century writer says, "of plants in general, their affections, parts, and differences, and not of each species in particular—a hard thing," because, in his own words, "there is nothing common to all plants as the mouth and belly to living creatures." After him came Dioscorides, in the time of Anthony and Cleopatra, whose excellent work on plants and the materia medica, edited and commented on by several writers, held its position until the seventeenth century as the leading work on the subject. Pliny provided for the Romans, in his renowned "Natural History," a cyclopædia of universal knowledge of the earth, about a third part of which is devoted to plants. Pliny was said to be credulous; he was certainly industrious and gathered a vast amount of information, but, I suppose, very few look into Pliny now-a-days, and yet his book contains many good things, and is the reverse of dry. The works of these two men and of Galen, who lived not very long after, supplied the botanical knowledge of Europe, except a little rill that trickled in from Avicenna and the Arabians, until about the sixteenth century, when a number of writers appeared, but their works are almost entirely founded upon the three above mentioned, except that of Cæsalpinus, who took Theophrastus for his model. In England the honour of the first work on Botany of any importance must be awarded to Dr. Turner, whose "New Herball" was published in 1551, in the reign of Edward the Sixth, and is dedicated "to the Duke of Somersette's grace." Turner is a quaint writer; he says, for instance: "Leopard's Bayne layd to a Scorpione maketh hyr utterly amazed and mum." Who would not carry a sprig of such an admirable remedy for "irresponsible chatterers?" The book is in black-letter, well-printed, and is illustrated with excellent outline engravings, which had, I believe, appeared before in the works of Fuchsius, published at Basle. The name of Fuchs has become a garden, if not a household word, in Fuchsia; and old Fox—for that would be his name in our vernacular—might be amazed that he also furnishes a patronymic for the intensely powerful aniline dye Fuchsine.

A pleasant paper might be written on those fine old folios, Gerarde's "Herbal" and Parkinson's "Theatrum Botanicum, or Theater of Plants," which appeared in the next century. Folios are out of date now except with book collectors who buy them, and with an occasional student who refers to them, but there is much diversified reading in these two volumes, as well as solid information, and they reflect great credit upon the troublous times in which they were issued. With them it may be said that the age of Dioscorides closes.

Up to this time very little system or arrangement is to be found in botanical works. Certain plants were so naturally and obviously associated that they were placed together, but beyond this there was not much attempt at order. The names of plants were also variable and unsettled; sometimes a species had only one name; occasionally they were numbered as *Brassica prima*, *B. secunda*, *B. tertia*, *B. quarta*, whilst often the name became quite a description, as *Chrysanthemum majus, folio valdè laciniato, flore croceo*, (*Anthemis tinctoria*, *L.*) Under these circumstances, the identification of specimens must have been difficult.

An English Botanist has the honour of proposing the first important step in the classification of plants. John Ray, the originator of the natural system of classification, published his *Methodus Plantarum Nova* in 1682. He instituted two great divisions of plants, namely, flowering plants, and plants that were flowerless, as ferns, mosses, lichens, &c. The flowering plants he again divided into Monocotyledons and Dicotyledons. For the benefit of my non-Botanical hearers I may say that the former are plants with one seed leaf, the latter with two. The young mustard plant when brought to table has two, and all grasses, oats, and barley, &c., only one. These differences may appear trivial, but they are accompanied by a totally different structure of stem, leaves, and flowers. Many of Ray's further groupings were adopted, but he persisted in some of the old errors. This great Naturalist—for he studied and wrote also upon animals, birds, fishes, and insects—lived for some years at Middleton Hall, near Sutton Coldfield, the seat of his friend and pupil Francis Willughby, and afterwards at Sutton. Whilst there he published his "Catalogue of British Plants," upon which all catalogues since published have been founded, and Warwickshire has thus the great honour of being the birthplace of English Botany, if not of that science itself under its modern aspect. I fear we have not much to show by way of memorial of his connection with our county. None of his Natural History works are, to my knowledge, in our libraries. We should endeavour to place them there. We have, however, the great and living monument raised by the Ray Society to his fame.

Tournefort, the eminent Botanist, was Ray's contemporary, and acknowledged the correctness of his views somewhat unreadily. The next great master was Linnæus, who failed to appreciate the importance of Ray's divisions of the vegetable kingdom. His own ingenious but purely artificial system has not survived. It was founded upon the arrangement of the parts of the flowers only, and consequently plants were brought into strange companionships. Ray, on the other hand, considered that every part of the plant—root, stem, leaves, and flowers—should be considered in natural grouping. The principal gift of Linnæus to Botany was the establishment of the genera upon a scientific basis. His introduction of the binary nomenclature was of the greatest value in bringing about a clear and systematic method for the distinction and arrangement not only of plants but of every class of living organisms. By it there was no occasion for *Brassica prima*, *secunda*, or *Brassica flore croceo*, but *Brassica* being the family or generic name, *Brassica alba*, *nigra*, *muralis*, &c., were the names given to the species.

Bernard de Jussieu arranged the genera of Linnæus into natural orders under the primary divisions of Ray. In 1827, Robert Brown discovered the direct action of the pollen tube upon the uncovered ovule of Conifers and Cycads, thereby affording a sure basis for the sub-division of Dicotyledons into two groups, Angiosperms and Gymnosperms, and in his various works he so greatly improved upon Jussieu's orders, that these two Naturalists stand first as the expositors of the natural orders of plants. Their classification, modified by the De Candolles, is usually adopted in this country and in America. In Germany the system of Endlicher, which is much less simple and is burdened with a cumbrous nomenclature, has been followed until recently. A new system is now in vogue, which is introduced into some of the class books published in this country. Such is a slight sketch of the natural system of classification; it possesses difficulties sufficient to attract the highest intellects, but anyone may obtain sufficient knowledge of it for the study of this branch of the science. As a sequence to this part of the subject I had intended to say something of the riches, the wonders, and the oddities of the vegetable world, but time obliges me to pass on.

"Stones grow, plants grow and live, animals grow, live, and feel." This is an ancient generalisation, but it hardly goes far enough, as some plants appear to feel after a fashion, even if they do not think. At present we have to concern ourselves with their lives in general. Every observer is acquainted with the external aspects of vegetable life. Heat and moisture are required for the germination of the seed, sunlight for the production of the leaves, flowers, and fruit. For the performance of the various functions of life a number of organs are necessary, and the differentiation during growth resulting in the formation of these various organs is termed vegetable Morphology, whilst the movements of sap, water, air, &c., and the chemical changes that take place in plants are considered under the designation of vegetable Physiology. From the time of Aristotle to that of Ray little was done in this branch of the work. Ray made, amongst other experiments, some on the flowing of sap. Cæsalpinus had also worked in the same direction. Henceforward the study of the life of plants advanced rapidly, but it is chiefly German Botanists of recent date who have advanced this part of the science. One of their countrymen says that the Germans have mostly concerned themselves with exact knowledge, rather than the discovery of general biological laws; and it was not a Botanist, but the poet Goethe, who, in his "Metamorphosis of Plants," struck out a new path. He there shows that the various parts of flowers are truly modifications of foliage leaves, and he therefore pointed out that all the endless varieties of plants may be said to have arisen from a single type, a simple fundamental form. Had he known that the leaf itself is built up of cells, he would have declared that the cell is the real fundamental organ, by the multiplication, transformation, and combination of which in the first place the leaf is formed, and that in the next by transformation, variation, and combination of leaves there arise all the varied beauties of form and colour which we admire in its green parts, as well as the organs of propagation in the flowers of plants. Is it to be wondered that this cell, this epitome of vegetable life, that is gifted with so wondrous a potentiality, should possess a certain amount of attractiveness even to many who have little or no scientific knowledge? Every cell is bound down by the laws of heredity, but is to a certain extent subject to adaptation under the power of surrounding influences. If anyone who has not done so, desires to examine a simple vegetable cell, let him take a little of the green stain so common on trees or old palings, which, in a drop of water under the microscope, is resolved into a multitude of round unicellular plants. The mode of multiplication of these may be observed, the use of the chlorophyll, which gives the beautiful green colour, and the formative powers of the protoplasm they contain. The work done is a type of that performed by all vegetable cells, for a plant is a system of individuals, each of which in its inception has a separate life.

Carlyle, in a striking, but somewhat fanciful passage, says: "All Nature and Life are but one garment, 'a living garment,' woven, and ever a-weaving, in the 'loom of Time.'" What precise idea Mr. Carlyle had, I do not pretend to say—that it was scientific is unlikely, for he always spoke contemptuously of science; nevertheless, the simile is fine, and the weaving still goes on, the loom is never idle. The warp and the woof are visible, but the motive power is hid in mystery. Some say that the pattern once set, never changes, though parts may fade out—that what it now is, it always has been. Others, that the work began with a slender, filmy thread, that it widened and spread out, forming the splendid garment it now is, perfect, but perhaps to become yet more perfect; that its work is automatic, and that it has written, and is still writing, in its every form and fashion, the history of its growth.

Let us hear what was said by one who took the latter view, and was the first to propound a well-considered and coherent theory of the development of organic life:

"Organic life beneath the shoreless waves
Was born, and nursed in ocean's pearly caves;
First, forms minute, unseen by spheric glass,
Move on the mud or pierce the watery mass;
Then as succesive generations bloom,
New forms acquire, and larger limbs assume;
Whence countless groups of vegetation spring,
And breathing realms of fin and feet and wing."

So wrote Dr. Erasmus Darwin, of Lichfield, the pioneer of the evolutionists, whose works were highly valued by his contemporaries as poetry, but the point of whose philosophy was altogether missed by them, for he was before his age. A little while ago his works appeared to be consigned to a well-merited obscurity, notwithstanding they abounded with original observations and reflections. Now, interest in them is again revived, but it is transferred from the poetry to the science. Dr. Darwin's philosophy was the antithesis of that of Ray, who wrote "The Wisdom of God in Creation"—a book on the evidences of Design—but as Botanists they had common interests, and the same stretch of country must have been familiar to both, as Middleton is not far from Lichfield.

Darwin was accustomed to travel over the country in his carriage, or on the old horse that ran loose behind, ready to be mounted when the roads became too bad to drive. Ray must have walked over the district, but he appears to have taken his "simpling" journeys on horseback.

Dr. Darwin was a prominent member of the celebrated Birmingham Lunar Society in the Augustan age of Birmingham science: Watt, Priestley, and, I believe, Wedgwood were the greater lights. Among the lesser, the eminent Botanist Dr. Withering, of the Old Square and of Edgbaston Hall, had a well-deserved celebrity. His "British Plants" ran through at least six editions, the sixth being edited by his son Wm. Withering, of The Larches, Sparkbrook, in 1818. Let this reminiscence of past grandeur induce us to emulate men who have left their mark upon science and upon our town. Our Town Council do not seem to remember it, as with this wealth of names to choose from they have called their *magnum opus* "Corporation Street." *O tempora, O mores !*

But to return to the garment of vegetation. How did it cover the earth ? Are there centres or zones of vegetable life ? Can the dispersal of plants be traced ? Has the character of the vegetation changed in different lands in the course of ages, and if so what have been the causes of the change ? Temperature, we know, has a marked influence on the economy of plant life, therefore a fall of temperature would be followed by the disappearance of many plants. Again, a rise of temperature would be followed by the disappearance of Arctic plants, except those left upon high mountains scattered perhaps over a large area. There are evidences of great changes in Britain. The Glaciers of the Cumbrian and Cambrian mountains once despatched their icebergs over the channel covering what is now mid-England. A great region that came under this cooling influence is now called the Palæarctic region, and it is so distinctly recognised that I noticed a bookseller's catalogue in which works relating to the Palæarctic region are classed together. So we must learn a new geography. Amongst eminent English Botanists who have written on the distribution of plants is our own member, Mr. W. Mathews, who has contributed an excellent paper on the Flora of Algeria. Let us hope that his next contribution may be laid upon our altar.

Let me give a few facts. As regards the British Isles, respecting which Mr. H. C. Watson is the chief authority, we have no flowering plants of accepted species that are peculiar to them alone. All are European except an orchid *(Spiranthes cernua,)* growing in the S.W. of Ireland, and the pipewort, *(Eriocaulon septangulare,)* a curious water plant, common in

North America but unknown to the European flora. The Irish filmy fern is also non-European, and is a native of the Azores.

About twenty species and sub-species of plants growing in Ireland are not met with in Britain, and, on the other hand, many British species have not reached Ireland. Some are restricted to the East of England, others have arrived on the south coasts and have travelled up the western shores; and, again, others are Alpine, scattered here and there on the highest hills. Some species are clearly natives, others colonists or aliens.

If we turn to the great continent of North America, we find that the flora as we pass southward from Canada through the United States does not alter essentially, but whilst becoming more luxuriant as we reach the extremity of Florida, it still preserves the character of a temperate flora. But if we cross the Straits to the Bahama Islands, a distance of only about fifty miles, we find that almost all the North American types of plants have disappeared, and that we are in the midst of a tropical flora mostly identical with that of Cuba. The inference of some former connection between these two last seems evident.

The discrepancies and resemblances between the flora of New Zealand and that of Australia, the nearest continental land, are so remarkable that their relationships have proved a difficult problem. New Zealand and Australia both possess temperate floras which have considerable resemblance, but apparently at some recent period Australia has acquired remarkable accessions, among them the Eucalyptus and other trees that give such a character to the Australian landscape. The tropical flora of New Zealand appears to have been derived from north-east Australia at a time when that part was separated from the temperate and southern parts by a channel, but united to New Zealand in a direction where the sea is still comparatively shallow. In many slands there is almost an identical flora with that of adjacent continents, indicating former union. In the Sandwich Islands, on the other hand, far away in mid-ocean, the flora is rich and almost three-fifths of the species are indigenous and peculiar to them. This indicates a very ancient flora, and that it may have originated in a much more extensive area than these islands at present possess. The newer part ot the flora possesses affinities with that of South America. It has been shown that seeds may be transmitted long distances by the waves, by birds, or by the winds. Arctic plants are transmitted by ranges of mountains. Some floras, for instance that of the Old World, seem to have a power of emigration and settlement similar to that of men of European origin. Sir J. Hooker traces the vegetation of Scandinavia from Lapland, by way of the Alps, the Caucasus, the Himalayas, and the mountains of the peninsula of India, to the Malayan Archipelago—and after a considerable hiatus to appear again on the Alps of New South Wales and Tasmania, in rapidly diminishing numbers it is true, but in vigorous development throughout. It matters not what the vegetation of the bases and flanks of the mountains may be, the Scandinavian asserts its prerogative of ubiquity from Britain to the Antipodes. This study of botanical geography, and the deductions that may be made from it, is becoming a question of the deepest interest in the researches of naturalists. It is so wide that it embraces the whole history of the past in geological times as well as in recent, and yet within the scope of a county a Botanist may find an ample field for investigations, as Mr. Bagnall has so ably shown us.

To those who are not interested in such far-reaching investigations, and to whom strictly technical Botany is also unattractive, glimpses into such secrets of Nature as the relationships of insects and flowers, may prove attractive. Every one knows why bees require flowers, but they may not know why flowers require bees. The flowers of many plants are self-fertilizing—that is, the pollen falls upon the stigmas when the latter are in a fit and mature condition to receive it. On the other hand, in many cases, either the one or the other of these organs matures a day or two the earlier. Such is the case in the common arum, now about to flower. The wide green sheath enclosing the singular columnar flower is inflated below, and the fringe of reversed hairs on the spadix allows flies to enter through the narrow throat, but prevents their return. They seek the honey from the ripened stigmas, taking their fill until the anthers ripen and the pollen is liberated; by this time the fringe of hairs has withered, and the flies are released, bearing their burden of pollen to another flower, where the stigmas may be in a fit state to receive it. You will often find many flies shut up in a flower. In the crocus you may see the bees busily worming themselves sideways round the anthers, which open outwards, covering their legs with pollen, and then invariably alighting on the stigmas of the next flower. In many flowers the floral organs are of different shapes. This is the case in the primrose, where some flowers have long stamens and short pistils, and in others this arrangement is reversed. This is also to ensure cross-fertilization, for Nature is "careful of the type." Into the flower of the meadow orchis the bee seeking for honey inserts his proboscis, at the same time detaching the pollen masses, which affix themselves to his head, by a viscid disc. At first they are reflexed, but shortly after recover, and bend forwards like the horns of a bull, ready to attack the stigma of the next flower the bee enters. These singular arrangements are well known, and have been shown at our meetings; but they may, perhaps, be new to some, and I wish to encourage in the young the habit of observation. The most curious of the provisions to be met with amongst orchids is that to be found in Catasetum, where, the pollinium being placed out of the reach of insects, the flower is provided with an antenna endowed with a peculiar sensitiveness, which, on being touched, loosens, as it were, the spring of the hidden pollinium, which is expelled with considerable force, striking the insect, and the disc adheres to his head. This singular bow will carry its arrow a distance of three feet. By the way, a state of tension is often met with in seed vessels, promoting the expulsion of the seeds. It is amusing to the uninitiated in *Noli me tangere*: disagreeable in the squirting cucumber; and, as I write in wintry weather, the memory of basking in the hot sunshine on a gorse-covered hill, listening to the sharp fusillade of the exploding pods, and soothed by the hum of insects, recalls a sense of bliss that only a Naturalist deserves to enjoy.

I must also mention the process in which fertilization is promoted by the wind, the pollen being carried in the air. Grasses and fir trees are wind fertilized, and we know what clouds of pollen are liberated when a branch of a fir or other catkin-bearing tree is rudely shaken, for it is obvious that a large quantity is required to ensure some of it reaching its destination.

There is yet another attribute of plant life that has recently engaged the attention of Botanists, namely, the power of movement. We know that flowers open and close with the sun, but that is commonly regarded as an effect rather that as being self-caused. We also consider leaves, living or dead, to be the sport of the winds, but to possess no power of voluntary movement.

The very meaning of the word to plant signifies to fix and make stationary. It is true the power of motion in plants is limited, but on the first protrusion of the radicle through the coatings of the seed, and during its whole growth, the plant is constantly in motion. This motion is termed circumnutation, and may be likened to that of a corkscrew. but describing ellipses rather than circles. Instantly the radicle of a germinating seed protudes its movement begins, and if the seed be lying on its side the motion is modified by attraction to the earth, and the point turns thitherwards. This spiral motion enables it to find a course amongst the obstructions it meets with as it lengthens and travels downwards. At the same time a number of very fine hairs are emitted from the upper part of the radicle, which firmly glue themselves to any small stones or suitable objects, giving it a purchase and enabling it to push forward. Seedlings are often subjected to a severe struggle for life, and it appears to be highly important that they should adapt themselves as quickly as possible to their conditions. The seedling then usually throws up seed leaves, and ultimately stems, true leaves, branches, and flower stems, all of which whilst young are constantly circumnutating. In climbing plants of vigorous growth the circumnutating movement is immensely increased, evidently to enable the stem to catch hold of a support. Secondary and tertiary radicles are gifted with somewhat different powers, but in all of them the point of extreme sensitiveness resides in the tip. I took up a primrose root the other day which had been planted about a fortnight, and found it covered in the meantime with young rootlets. Imagine this multitude of delicate white threads, each of them carefully searching amidst the coarse earth for the path of least resistance, and it will give us an idea of the wonderful mechanism of even these out-of-sight parts of plants. In the sleep of plants leaves often arrange themselves in a variety of positions, in many instances evidently in order to avoid the effects of radiation, which would act more powerfully and produce greater cold were the leaves in a horizontal position. This is also regarded as a modified circumnutation. There is another class of movement in leaves, that which causes them to change their position and present their edges to the light during the brightest period of the day, which is sometimes called the diurnal sleep of plants. In a species of Silphium during the devolopment of the leaves the petiole is twisted so that the blades face east and west and their edges north and south. The flower heads are almost always turned eastwards. Sir J. Hooker states that in travelling by rail any alteration in the direction of the road becomes apparent by the altered appearance of the leaves of the "compass plant."

These are some of the movements which have been observed in plants, but the most striking resemblance to the movements of animals occurs when an influence is transmitted from one part of a plant on its being excited to another more or less distant, which moves in response, as is the case of the sensitive Mimosa, the Dionæa, and other plants. Plants do not possess a nervous system, and movements must consequently be transmitted by an alteration in the condition and consequently in the form of the cells, but why a touch should cause a change, and why its effect should travel so instantaneously is not known.

Such are a few of the directions in which we may trace the workings of the wonderful power known as vegetable life. I have done little more than indicate certain paths of research amongst many that abound in variety and beauty. I have been obliged to leave out so much that I fear I may not have made all I have said clear to those who have hitherto paid but little attention to Botany. My object has been specially to attract such, and to show them that in Botany there is to be found something more than hard words and dry catalogues of plants. The range of the subject is magnificent. On land—from the Chlorococcum, the green stain I mentioned, to the towering Wellingtonia or Eucalyptus; in the water—from the minute desmids and diatoms, a world of beauty in themselves, to enormous seaweeds extending their branches to many hundreds of feet; above—from the red snow on the highest mountains, to the black fungus at the bottom of coal mines beneath; in time (leaving fossil plants out of consideration)—from a life of a few hours to an existence of a thousand years. Beautiful—hideous; delicious—disgusting; useful beyond all knowledge—a pest and a terror; wholesome as food in every degree—or poisonous in the same; health-giving—or health-destroying; almost every epithet we can think of may be exhausted upon those wonderful productions of nature; and yet there are many people, even educated people, to whom one plant is pretty much as another plant, one flower as another flower; and, indeed, of whom the well-worn verse still runs true:—

"A primrose by the river's brim
A yellow primrose was to him,
And it was nothing more."

To remove such a stain upon our intelligence and cultivation has always been one of the objects of our Society, and in vacating this honourable office, I rejoice that I shall still be the companion of so many who have laboured both for the discovery of new wonders and for the enlightenment of their brethren.

TWENTY-SECOND ANNUAL REPORT

OF THE

BIRMINGHAM

NATURAL HISTORY & MICROSCOPICAL SOCIETY,

READ AT THE

ANNUAL MEETING, HELD FEBRUARY 1st, 1881.

Although during the past twelve months the energies of the Society have been somewhat impaired by the loss of their usual meeting-room, and the changes and temporary inconvenience to which they were subjected, yet the work of the year has not been seriously interfered with; while with the greatly increased advantages now available to the members, there is ground for the expectation that in the near future there will be greater activity and usefulness than in any former period of the Society's existence.

The chief event of the year has been the removal of the Society from the Midland Institute, where the necessary accommodation could no longer be afforded them, to the new Science College, established by the munificence of Sir Josiah Mason. Here the Trustees of the College have granted them a large and convenient room for their exclusive use, together with the permission to hold their General and Sectional Meetings in the Biological Theatre, which affords ample accommodation for the largest number likely to attend.

With a view adequately to recognise the generous spirit in which the Committee was dealt with by the Trustees of the Mason College, they, with the unanimous approval of the members, decided to furnish the Society's Room in a substantial and fitting manner. A small Sub-Committee was appointed to carry out the wishes of the members; and how well they have earned the heartiest thanks of the Society has been recognised, in the most satisfactory manner, by the approval of what they have done, shown by the members generally. Mr. J. A. Cossens rendered valuable assistance to the Society by furnishing suitable designs for the Book-case and Cabinet, which Messrs. Marris and Norton carried out. The total cost of furnishing is £280, towards which the members have subscribed £165 13s. 6d., leaving £114 6s. 6d. to be provided. It is most desirable that this liability should be paid off without having recourse to the ordinary income of the Society, which is not more than sufficient to enable the Society to profit by its improved opportunities of usefulness.

The first meeting at the College was held on October 5th, when 127 members and friends were present, nearly filling the Theatre. After the President had delivered a short address, Professor T. W. Bridge, on behalf of the College authorities, warmly welcomed the Society to its new home.

The Committee desire especially to call the attention of the members to the fact that the Society's room, which has been fitted up as a Library and Committee Room, is now opened daily, from twelve to three P.M., under the charge of the Sub-Curator. Here the members may sit, read, or write comfortably. The books, magazines, microscopes, microscopic slides, and other apparatus are ready for their use or consultation; and the Sub-Curator is empowered to issue and receive the books lent from the Library, and also to receive the subscriptions due to the Treasurer.

The Committee desire to place on record their warm sense of indebtedness to the Council of the Midland Institute for the uniform kindness shown to this Society during the many years its meetings were held at the Institute. The hearty thanks of the members have already been expressed by a unanimous resolution which the Committee forwarded to the Hon. Sec. of the Council.

During the year the laws of the Society have been revised. Two changes of importance have been made: 1st, the admission, as Associates, of young persons between the ages of fourteen and nineteen, who enjoy, without payment of any subscription, all the privileges of membership, except that of voting; 2nd, the creation of a body of seven Trustees, in whom the property of the Society will be vested by deed. The following were elected Trustees at a Special Meeting of the Society held on August 10th, 1880, namely:—Messrs. E. W. Badger, W. Graham, W. R. Hughes, J. Levick, C. Pumphrey, W. Southall, and E. Tonks.

The Committee have great pleasure in calling attention to the fact that, in accordance with the arrangement mentioned in the Report of last year, all the papers written during the present year by members for the "Midland Naturalist," or read before the Society and afterwards published in that magazine, will be reprinted and bound up with this Report.

Nineteen Committee Meetings and eighteen Sub-Committee Meetings have been held, and the attendance has been as follows:—

		Summoned.	Attended.
President	Mr. W. Southall	35	17
Vice-Presidents	Mr. E. W. Badger	25	9
	Mr. J. Levick	37	36
Treasurer	Mr. C. Pumphrey	25	16
Librarian	Mr. J. E. Bagnall	31	29
Curators	Mr. W. B. Grove	27	18
	Mr. R. M. Lloyd	27	21
Sec. Biol. Section	Mr. J. F. Goode	25	18
,, Geol. ,,	Mr. T. H. Waller	25	8
Hon. Secs.	Mr. J. Morley	37	34
	Mr. H. E. Forrest	30	23

Elected Committee.

	Summoned.	Attended.
Mr. W. G. Blatch	19	16
,, W. Graham	37	27
,, W. R. Hughes	37	28
,, W. P. Marshall	19	2
,, E. Tonks	34	19
A. W. Wills	35	15

Two Day Excursions have been made:—On Easter Monday, to Evesham and the banks of the Avon; and on Whit-Monday, to Warwick and Stoneleigh. Five Half-day Excursions have also been made.

It has been suggested that a Marine Excursion be organised for 1881, the time to be the first week in July, and the place Oban or its neighbourhood.

At the end of the year 1879, the Society numbered 339 members, including two Honorary Vice-Presidents, twenty-five corresponding members, and four life members. There have been sixty new members elected, including Prof. Huxley, Mr. Herbert Spencer, and Prof. C. C. Babington as Honorary Vice-Presidents, and Rev. W. H. Dallinger, Messrs. H. J. Carter, W. Phillips, G. C. Druce, and Richard Wright, as corresponding members. There have been also ten associates added to our numbers. The Society has lost one life member by death, and thirty-seven members have resigned. The total number of members and associates is now 371, so that there has been a net increase of thirty-two.

During the year there have been twenty-nine General Meetings, with an average attendance of thirty-one, at which sixteen papers have been read, as follows:—

On some of the more remarkable Infusoria captured during the Falmouth Excursion, 1879	W. Saville Kent, F.L.S., F.R.M.S.
Water Plants: their office in Nature and uses in Aquaria	H. W. Jones, F.C.S., F.R.M.S.
Abstract of the Researches of Prof. A. Weissmann into the habits and life-history of *Leptodora hyalina* ..	Arthur M. Marshall, D.Sc.
Some Phenomena of Ice	W. B. Grove, B.A.
On the changes in Plumage of some of the British Birds	R. W. Chase.
Two of our Garden Pests—the Gooseberry Saw-fly and the Currant Moth	W. G. Blatch.
A cheap and useful Entomological Cabinet	W. G. Blatch.
The Desmidieæ of Sutton Park ..	A. W. Wills.

Notes on *Anuræa longispina*, *Ceratium longicorne*, and other Microscopic Organisms, from the town water-works water	J. Levick.
On the Chemistry of the Shells of some Crustacea	H. W. Jones, F.C.S., F.R.M.S.
On Sponges, followed by an account of the Sponges dredged during the Falmouth Excursion, 1879 ..	H. J. Carter, F.R.S.
(*Communicated by* Mr. W. R. Hughes.)	
On *Spirogyra nitida*	Rev. J. E. Vize, M.A.
Notes on the Mineralised Diatoms found by Mr. W. H. Shrubsole, F.G.S., in the London Clay ..	J. Edmonds.
A rare British Entomostracon, (*Ilyocryptus sordidus*)	H. E. Forrest, F.R.M.S.
Molluscan Palates, and the mode of obtaining them	Chas. Pumphrey.
Notes on the Flora of Bournemouth	W. H. Wilkinson.

The following are the chief specimens exhibited at the General and Sectional Meetings during the year. Those marked with an asterisk (*) are new to Warwickshire.

Mr. J. E. Bagnall, Phanerogams:—*Avena elatior*, showing phyllody of the lower paleæ; *Radiola millegrana*, from Berkswell; *Oxalis Acetosella, (forma purpurea,)* from Bushwood; *Viola Reichenbachiana*, from Lapworth Street; section of Stigma of *Mimulus luteus*, to show pollen tubes, and a Stigma of the same, bearing the mixed pollen of *Œnothera*, *Mimulus*, and *Tropæolum*: **Centunculus minimus*, *Sagina apetala*, *Arundo Epigeios*, and *Mentha arvensis*, all from near Coombe Abbey; and *Rubus foliosus*, from Hartshill. Cryptogams, (Mosses):—Antheridia of Sphagnum, and Antheridia and Archegonia of *Mnium subglobosum*: *Pogonatum nanum* and *Bryum roseum* from Marston Green; *Fissidens exilis* (rare) and *F. Orrii* (new to science;) *Ulota intermedia*, from Shelly Coppice; *Mnium rostratum*, and *M. punctatum* in fruit; *Plagiothecium latebricola* and *Gymnostomum tenue*, from Berkswell; *Hypnum giganteum*, from Old Park, Warwick; *Buxbaumia indusiata*, *B. aphylla*, *Georgia pellucida* in fruit, and *G. Brownii*; (Hepaticæ):—Antheridium of *Diplophyllum albicans*, from Solihull; **Pellia calycina*, **Aneura sinuata*, **A. multifida*, and its var. **ambrosioides*, from near Honily; **Jungermannia crenulata*, from Berkswell; and sections of *Marchantia polymorpha*, showing hitherto unnoticed peculiarities of structure.

Mr. W. G. Blatch, *Pœcilocampa populi*, from Knowle; *Pogonocherus hispidus*, from Sare Hole, Moseley, found March 14th; **Coccinella ocellata*, from Coleshill; **Megacronus cingulatus*, from Sutton Park; *Saperda populnea*, and Aspen Twigs infested with its Larva; **Diphyllus lunatus* and **Plegaderus dissectus*, found in a fungus (*Hypoxylon concentricum*) at Knowle; **Bembidium quinquestriatum*, from Olton; **Ptinella denticollis*, from Knowle; **Ocypusa picina*, and **Donacia comari*, from Sutton Park; and *Chirocephalus diaphanus*, from Knowle.

Mr. T. Bolton, *Pycnogonum littorale*, from Dundee; *Zoothamnium dichotomum*, from the Aston Aquarium; *Gordius aquaticus*: a marine Polyzoan, *Bowerbankia gracillima*, and a species of Follicularia; *Argulus foliaceus*, from Kingswood; Zoëa-stage of Shore Crab; *Nymphon gracile*: the Cydippe; *Perophora Listeri*, from Ventnor; *Syncoryne gravata*, *Clava squamata*, *Noctiluca miliaris*, and numerous Rotifers.

Professor T. W. Bridge, a large collection of Fishes, Reptiles, and Invertebrata, preserved in spirit, including Ceratodus, Lepidosteus, Anableps, &c.

Mr. Montagu Browne, Baleen from the Jaw of the Whale, (*Balænoptera musculus*,) then being exhibited in Birmingham, (April;) three living Bats, (*Plecotus communis*:) a living Slow-worm, (*Anguis fragilis*:) a male Sheldrake, (*Tadorna Vulpanser*:) a Gannet, (*Sula bassana*,) from the Aston Aquarium; young and old specimens of the Albatross, (*Diomedea exulans*,) from the Australian Seas; the Giant Petrel, (*Ossifraga gigantea*,) from New Zealand; and *Saturnia Pyri*, hitherto unrecorded in the British Isles, caught in a timber-yard in Birmingham.

Mr. R. W. Chase, *Alauda alpestris*, the Shore Lark, and *Emberiza lapponica*, the Lapland Bunting, taken near Brighton; *Motacilla flava*, the Blue-headed Wagtail; *Melizophilus Dartford-*

iensis, the Dartford Warbler; and the Peregrine Falcon, shot near Bridgnorth.

Mr. I. J. Cotton, a living Green Snake (*Natrix torquata*) from Kenilworth.

Mr. H. E. Forrest, living specimens of the medusiform larvæ of a species of Obelia, growing on the Arctic crabs in the Aston Aquarium, and also spawn of Perch from the same place; *Botryllus polycyclus*, a marine compound ascidian *Ilyocryptus sordidus*, a rare Entomostracon, and many Polyzoa and Rotifers.

Mr. J. F. Goode, Foraminifera from sand dredged during the Falmouth Excursion; an objective by Zeiss, which could be altered from a 4in. to a 2in. power by turning a screw collar; a Queen Termite, or White Ant, from Natal, and workers of the same species.

Mr. W. Graham, *Idolocoris elephantis*, a parasite of the elephant, and an objective similar to that exhibited by Mr. Goode.

Mr. W. B. Grove, *Gonium pectorale*, and a species of Bursaria; *Æcidium depauperans*, Vize, a fungus parasitic on Viola.

Mr. W. R. Hughes, Egg Capsules of one of the gooseberry grubs, (*Nematus grossulariata*,) showing the caterpillars escaping from the egg.

Mr. H. W. Jones, female Arctic Stone Crab, (*Lithodes Arctica*,) from the Aston Aquarium; Paraguay Tea, the produce of *Ilex Paraguayensis*; and the River Lamprey.

Mr. J. Levick, *Dinobryon Sertularia*, *Rhipidodendron Huxleyi*, *Pandorina Morum*, *Podophrya quadripartita*, *Anuræa longispina*, *A. curvicornis*, *Polyarthra platyptera*, and *Ceratium longicorne*: an Amœba of extraordinary size; *Uroglena Volvox*, from Sutton Park; *Leptodora hyalina*, from the Canal at Tanworth and Earlswood Reservoir, and many other microscopic organisms.

Mr. W. P. Marshall, the Pod of the Milk-weed, *Asclepias cornuti* from Canada.

Mr. John Morley, Larva of Ephemera, and the fourth series of varieties of Nature-printed British Ferns.

Mr. C. Pumphrey, *Paris quadrifolia*, from Hopwood Dingle; *Aster alpinus*, *Gnaphalium Leontopodium*, (the Edelweiss,) and a Dianthus grown from Swiss plants.

Mr. W. E. Richardson, a large collection of Ferns from Jamaica.

Mr. W. Southall, *Veratrum album*, the plant from which the Hellebore powder of commerce is obtained; the remarkable flowers of three species of Ceropegia, (Asclepiadaceæ;) leaf of *Durio zibethinus*, the plant which produces the celebrated Durian fruit; *Tacsonia Van-Volxemi* in fruit; and nest of the Reed Warbler, from Sir Harry's Road, Edgbaston.

Mr. G. W. Tait, *Vorticella chlorosigma*, the green Vorticella, from Knowle.

Mr. Lawson Tait, metacarpal bones from the hand of a horse, united by an osseous deposit.

Mr. W. H. Wilkinson, *Hippocrepis comosa*, from near Cheltenham; *Corydalis claviculata*, from the Lickey Hills; *Pisidium cinereum*, from this district; and *Psammobia Ferroensis*, from Bridlington Bay.

Mr. A. W. Wills, *Asterionella Bleakeleyi*, from Falmouth; *A. formosa*, from Sutton; *Hæmatococcus binalis*: and *Staurocarpus gracilis*, in conjugation: and some new and rare Desmidieæ from North Wales.

Mr. Wright Wilson, six Ligules, or immature Tape-worms, from the Roach.

JOHN MORLEY,
W. B. GROVE, B.A., } Hon. Secretaries.

BIOLOGICAL SECTION.

There have been nine meetings of the Section during the year, the attendance at which has been generally good, an average of twenty-seven members having been present.

An improvement, however, has been manifested in this respect since the removal of the Society, in October last, to Sir Josiah Mason's Science College, the average attendance at the last three meetings being thirty-five; showing conclusively the advantage of the improved accommodation afforded. Seven papers have been read, as follows:—

On *Strongylus nodularis.* (Communicated by Mr. Lawson Tait.)..	Dr. T. Spencer Cobbold, F.R.S.
On the Work of the Society ..	E. W. Badger, F.R.H.S.
On the Study of the Lichens. (Communicated by Mr. J. E. Bagnall.)	W. Phillips, F.L.S.
Resumé of Dr. Siemens' Experiments as to the Influence of the Electric Light upon Vegetation ..	W. P. Marshall, C.E.
On the Changes in Plumage of Birds..	Montagu Browne, F.Z.S.
On some New and Rare Desmidieæ from North Wales	A. W. Wills.
Observations on the Record of Phenological Phenomena	W. B. Grove, B.A.

A number of valuable and interesting specimens have been exhibited, but often through want of time they have not had the attention they deserved. It would add much to the interest and usefulness of our meetings if more time could be spared for the examination and discussion of specimens.

As a whole the work of the Section during the session may be considered satisfactory, and gives promise of more extended usefulness in the future.

It is to be hoped that the liberal offer of the Professor of Biology, to place one of the laboratories of the College at the disposal of Members engaged in any special line of research, will be taken advantage of, and that results will be obtained which will tend to clear up some of the vexed problems of Biology, or at least furnish some important links in the chain of evidence.

JOHN F. GOODE, Sec. Biological Section.

GEOLOGICAL SECTION.

This Section has held eleven meetings during the past year, with an average attendance of twenty-five members.

The chief feature of the meetings has been the beginning of a series of papers on Geology, in which it is intended, as far as possible, to review the whole of that science.

The following have been delivered :—

Introductory :—On the Study of Geology	By Dr. Deane.
The Older Rocks of Charnwood Forest	By Prof. Bonney, of Cambridge.
Coal	By Mr. W. Madeley, of Dudley.
Igneous Rocks	By Mr. Thos. H. Waller, B.A., B.Sc.

Considerable interest has been shown in the papers already delivered, and several others are promised.

Two papers have been read on other subjects :—

Mineralogy of Cornwall	By Mr. W. Cotterell, F.R.A.S.
Botanical Tours in Ireland in 1876-7 and 9	By Rev. J. Caswell.

T. H. WALLER, Hon. Sec.

CURATORS' REPORT.

During the past year, two binocular microscopes, one made by Crouch and the other by Swift, each with two objectives and accessories, have been purchased by the Society. Both have been used at most of the meetings, and have given general satisfaction, and are, in fact, excellent instruments. A pair of Ross' B eyepieces have also been bought. The Ross instrument is in perfect order, but the four Collins microscopes are not by any means perfect, and, as they have during the past few years been twice overhauled, the defects would seem to be inherent. We would, therefore, advise that no more money should be spent upon them, but that, as they work fairly well as monoculars, and will do for exhibiting objects that do not require first-class instruments or high powers, the recommendation in the suggestion-book that several small microscopes be purchased be not complied with, but more instruments of a better class be bought as funds will allow.

A cabinet to hold about 1,200 slides has been ordered. Mr. Wills and others have already promised valuable contributions of slides; Mr. F. Enock has presented during the past year a number of his beautiful insect preparations, and it is hoped that the members generally will do their best, by giving liberally of their own mounted specimens, to make the collection a thoroughly useful and representative one, and thus fill a long-felt want, which is now all the more urgent, as members can have access to the microscopes and objects each day.

The following presents, besides those mentioned above, have been made to the Society:—A microscope lamp, by Mr. Graham; and a collection of 38 birds, from South Africa, by Mr. B. J. Glainville, of Graham's Town.

W. B. GROVE, B.A.
R. M. LLOYD.

THE LIBRARIAN'S REPORT.

Having recently examined the books in the Library, I am able to report favourably as to its condition.

The issue of books during the past year has not been so great as one could desire. This is, probably, due to the fact that our Library was inaccessible to members for several weeks prior to our removal to our present rooms. The issue has been as follows:—58 Botanical, 3 Conchological, 5 Entomological, 21 Geological, 52 Microscopical, 45 Zoological, and 55 General Science—total, 239.

The total issue of the past year exceeded that of recent years, and shows a greater percentage of books belonging to special subjects issued than heretofore.

The increased facilities for the issue of books, recently sanctioned by your Committee, will, I think, materially increase the usefulness of your Library.

Your Committee have been as liberal to the Library during the past year as the means at their disposal would allow; and have placed upon the shelves many valuable works, the following having been purchased:—Human Physiology, Carpenter; The Crayfish, Huxley, (large edition;) ditto, ditto, (small edition;) Solar Physics, Lockyer; White's Natural History of Selborne, (Buckland's edition;) Journal of a Naturalist, Knapp; Primitive Man, Figuier; Introduction to the Study of Cryptogamous Plants, Sprengel; Biological Atlas, D. and A. N. McAlpine; Degeneration, Ray Lankester; Geology and Physical Geography of Great Britain, Ramsay; Monthly Microscopical Journal, Vols. 1 to 18; Linnean Society's Proceedings, Zoology, Parts 75 to 80; Botany, Parts 99 to 105; Midland Naturalist, Vols. 1 and 2, two copies; Prehistoric Man, Professor Wilson; Glaciers of the Alps, Professor Tyndall; Text Book of Botany, Prantl and Vines; Moss Flora of Great Britain, R. Braithwaite, M.D., Parts 1 to 3; The Phytologist, first series, Vols. 1 to 5; ditto, new series, Vols. 1 to 6; Island Life, A. R. Wallace; Palæontographical Society's Volume for 1880; Ray Society's Volume, 1880—a Monograph of the Free and Semi-parasitic Copepoda of Great Britain, G. S. Brady; Zoological Record, Vols. 2, 3, 5, 7 to 14, (to complete our series;) Reports of the British Association, 1831, 1833, 1837, 1838, 1839; Annals and Magazine of Natural History; Journal of Botany; Entomologists' Monthly Magazine; The Entomologist; Grevillea; Monthly Journal of Science; Science Gossip; Nature; The Zoologist; The Quarterly Microscopical Journal; and Popular Science Review, (parts as issued.)

The following have been presented:—The English Mechanic, Vols. 16 to 25, by Mr. J. F. Goode; Report of the United States Geological Survey of the Territories, F. V. Hayden, by the United States Government; Old Stones, Rev. W. S. Symonds, by the Author; The Flora of Algeria, Wm. Mathews, M.A., by the Author; The Proceedings of the Royal Microscopical Society, (parts as issued,) by the Society; thirty-five Papers, on Sponges, Foraminifera, &c., reprinted from the Annals and Magazine of Natural History, H. J. Carter, F.R.S., by the Author, per Mr. W. R. Hughes.

JAMES E. BAGNALL, Hon. Librarian.

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CHARLES DARWIN, LL.D., F.R.S.

T. SPENCER COBBOLD, M.D., F.R.S.

T. H. HUXLEY, LL.D., F.R.S.

CHARLES CARDALE BABINGTON, M.A., F.R.S.

HERBERT SPENCER.

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President: EDWARD W. BADGER.

Vice-Presidents:
JOHN LEVICK. THOS. H. WALLER, B.A., B.Sc.

Ex-Presidents (who are Vice-Presidents:)
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W. GRAHAM, F.R.M.S. W. SOUTHALL, F.L.S., F.R.M.S.

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J. F. GOODE.

Secretary of Geological Section:
A. H. ATKINS, B.Sc.

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W. G. BLATCH.
T. W. BRIDGE, M.A.
R. W. CHASE.
W. J. HARRISON, F.G.S.
A. W. WILLS.

LIST OF THE MEMBERS

OF THE

BIRMINGHAM

NATURAL HISTORY & MICROSCOPICAL SOCIETY,

JANUARY, 1881.

Those Members whose names are marked with (P) have been Presidents of the Society; those with (L) are Life Members; those with (C) are Corresponding Members; those with (*) are Guinea Subscribers; and those with (†) are Subscribers to the Apparatus and Library Fund.

NAME.	ADDRESS.
†Adams, Rupert	Grosvenor Road, Handsworth.
Ady, Ernest, M.A.	The Mason College.
Albright, G. S., B.A.	Mariemont, Edgbaston.
Allday, Edmund	Park Road, Solihull.
Allday, John	The Oaks, Handsworth Wood.
Allday, William	330, Coventry Road, Birmingham.
Allen, W. S.	35, Waterloo Street.
Allport, Samuel, F.G.S. *(P)* ..	The Mason College.
Allport, S. B.	Whittall Street.
Anderton, J.	99, Suffolk Street.
†Anthony, John, M.D., M.R.C.P.	Greenfield Terrace, Edgbaston.
Antrobus, P.	Church Hill, Handsworth,
Atkins, A. H., B.Sc.	King Edward's School.
Atkins, E.	Woodside, Handsworth Wood.
Avery, Alderman, J.P.	Church Road.
Babington, C. C., M.A., F.R.S., *(Hon. V.P.)*	Cambridge.
Badger, A. Bernard	Mostyn Villa, Moseley.
†Badger, E. W.	Office of *Midland Counties Herald.*
Badger, E. W., Jun., B.A. ..	Mostyn Villa, Moseley.
Bagnall, Jas. E.	84, Witton Road.
Bain, Rev. W. J	Mount Pleasant, Bilston.

Baker, Harold	101, Gough Road, Edgbaston.
Ball, Henry	74, Gough Road.
Barclay, Hanbury	Anchor Tube Co., Gas Street.
Barclay, Thomas	Moseley Road.
Barratt, J. O. W.	Exeter Row.
Barrodale, S.	King Edward's School.
Barrows, Joseph, jun.	Kingsbury House, Birchfield.
Baxter, J. H.	15, Alston Street, Ladywood.
Bayfield, Arthur	32, Temple Row.
Beale, Dr. L., F.R.M.S. (*C*) ..	61, Grosvenor Street, London, W.
Bennit, P. Wilmot, M.A., F.Z.S.	South Road, Smethwick.
Berkeley, Rev. M. J., M.A., F.L.S. (*C*)	Sibbertoft, Market Harborough.
Bevan, Rev. J. O.	72, Beaufort Road.
Birkmire, T.	107, Albert Road.
Blakemore, J.	Oban House, Ladywood Lane.
Bland, T. F.	High Street, Stourbridge.
Blatch, W. G.	Albert Villa, Green Lane.
Bolton, Thomas, F.R.M.S. ..	57, Newhall Street.
Bragge, W., F.S.A.	Shirle Hill, Handsworth.
Braithwaite, Dr. (*C*)	The Ferns, Clapham Rise, S.W.
Brierley, Leonard	Holmeswood, Somerset Road.
Bridge, T. W., M.A.	The Mason College.
Brittain, H.	Alston Street, Ladywood.
Brittain, Henry	George Street West.
Brodie, Rev. P. B., M.A. (*C*) ..	Rowington, Warwick.
Brown, G. J.	Bath Row.
Browne, Montagu, F.Z.S. ..	Leicester Museum.
Brown, Wm.	Waterloo Street.
Bullus, W., M.R.C.S.	High Street, West Bromwich.
Burgess, J. Tom, F.S.A. (*C*) ..	Bath Villa, Worcester.
Burman, R. H.	17, Temple Street.
Callaway, C., D.Sc, F.G.S. (*C*) ..	Wellington, Salop.
Caldwell, George	34, Worcester Street.
Carter, H. J., F.R.S. (*C*) ..	Budleigh Salterton, Devon.
Cashmore, G. T.	74, Ravenhurst Street.
Caswell, C. B., F.C.S.	13, George Road, Edgbaston.
Caswell, Rev. John	St. Mary's College, Oscott.
†Chase, R. W.	2, Edgbaston Road, Edgbaston.
Chamberlain, Henry John ..	78, Sumner Road, Edgbaston.
Chamberlain, R.	Westbourne Road, Edgbaston.
Chitty, E. J.	39, Bennett's Hill.

Christy, Cuthbert .. .. .. 8, Wheeley's Road.
Clarke, Ann E., M.D. .. .. Hospital for Women, Spark Hill.
Clarke, J. B. .. .. .. Henley Lodge, Handsworth.
Clarke, T. .. .. 187, Moseley Road.
Clayton, F. C. .. .. .. 18, St. James Road.
Cobbold, T. Spencer, M.D., F.R.S. (*Hon. V.P.*) .. .. 74, Portsdown Road, Maida Hill, London, W.
Collens, E. .. .. .. Holly Lane, Erdington.
Collins, J. T. .. .. .. Church Field, Edgbaston.
Cooksey, J. H. .. .. .. West Bromwich.
Corser, Benj. .. .. .. 42, Cherry Street.
†Cotterell, Wm., F.R.A.S. .. 17, Park Street, Walsall.
Cottrell, J... .. .. .. 176, Ashted Row.
Cotton, I. J. .. .. .. 10, Great King Street, Hockley.
Cotton, J. W., F.G.S. .. .. Exdale, near Coventry.
Cox, W. H. .. .. .. 150, Newhall Street.
Creasey, H. .. .. .. Tower Road, Aston Park.
Cresswell, A. N. .. .. .. 2, York Road, Edgbaston.
Crofts, George .. .. .. The Cedars, Trafalgar Road.
Crompton, Henry D. .. .. Beaufort Road, Edgbaston.
Crosskey, Rev. H. W., F.G.S. (*P*) 28, George Road, Edgbaston.
Cumberland, T. .. .. .. Dorset House, Harborne.
Dallinger, Rev. W. H. .. .. Wesley College, Sheffield.
Darwin, Chas., LL.D., F.R.S. (*Hon. V.P.*) .. .. .. Down, Bromley, Kent.
†Davis, Geo. E. (*L*) .. .. Dagmar Villa, Heaton Chapel, Stockport.
Deane, Rev. G., D.Sc. (*P*) .. Spring Hill College, Moseley.
Druce, G. C., F.L.S. (*C*) .. High Street, Oxford.
Dugard, William .. .. .. Lower Loveday Street.
Duignan, W. H. .. .. .. Walsall.
Dunn, F. W. .. .. .. 97, Camden Street.
Edmonds, John .. .. .. General Cemetery.
Enock, F. (*C*) .. .. .. 30, Russell Road, Seven Sisters' Road, Holloway, London, N.
Everitt, Allen E... .. .. City Chambers, 82, New Street.
Evett, James .. .. .. The Elms, Handsworth.
Farrow, William .. .. .. 192, Gooch Street.
Fletcher, Dr. Bell (*L*) .. .. 7, Waterloo Street.
Forrest, H. E., F.R.M.S. .. Lloyds Banking Company, Welshpool.
Ford, J. .. .. *Chronicle* Office, Wolverhampton.
Ford, William Henry .. .. Beaumont Terrace, Merridale, Wolverhampton.

Fowke, F. (*C*)	161A, Strand, London, W.C.
Francis, Mrs.	Wheeley's Road.
Francis, Miss	Wheeley's Road.
Fraser, Dr. J. (*C*)	Chapel Ash, Wolverhampton.
Fretton, W. G., F.S.A. (*C*)	Coventry.
† Fry, Henry A.	117, Gough Road, Edgbaston.
Gargory, J.	Bull Street.
Gibbins, John	31, Frederick Road.
† Gibbons, W. P.	Athol House, Edgbaston.
Glainville, B. J. (*C*)	Albany Museum, Grahamstown, South Africa.
† Goode, A. C.	Emsley, Greenhill Road, Moseley.
Goode, Ernest	TheMoors,Church Lane, Handsworth.
† Goode, J. F.	TheMoors,Church Lane, Handsworth.
Goode, J. T.	TheMoors,Church Lane, Handsworth.
Goode, Miss	34, Frederick Road.
† Graham, Walter, F.R.M.S. (*P*)	Ludgate Hill.
Grant, William T.	The General Hospital, Birmingham.
Greening, Alf. T.	Bath Villa, Stratford Road.
Greenway, J. F.	28, Wheeley's Road.
Griffiths, A. H.	Thornbury, Woodbourne Rd., Edgbaston.
Grove, W. B., B.A.	Cheadle Cottage, Perry Barr.
Hadley, F.	Hamstead Lodge, Handsworth.
Hadley, Philip	41, Beaufort Road.
Hadley, Miss A.	Hamstead Lodge, Handsworth.
Hale, W.	King's Norton.
Hall, A.	Edith Villa, Albert Road.
*Hall, William Foley	Hall Road, Handsworth.
Hardiker, W. A.	Albion House, Rookery Rd., Handsworth.
†Harding, Rev. Isaac	Smethwick.
Harrison, W. J., F.G.S.	Golden Hillock Road.
Harrold, William	324, Bristol Road.
Hassall, T. H.	Belmain House, Trafalgar Road, Moseley.
Hatton, T. S.	Waterloo Road S., Wolverhampton.
Hawkes, Henry	Northfield.
Haydon, W. F., F.C.S.	The Exchange.
Hayes, E. J.	Ashley House, Handsworth.
Heaton, James	Union Passage.
Heaton, George, J.P.	Church Hill, Handsworth.
Heaton, Mrs. George	Church Hill, Handsworth.
*Heaton, Harry	Harborne House, Harborne.
Heaton, Alderman, J.P.	Courtlands, Edgbaston.

Heaton, Mrs.	Courtlands, Edgbaston.
Heslop, T. P., M.D.	Temple Row.
Hickinbotham, Dr.	26, Broad Street.
Hill, Alfred, M.D., F.C.S. ..	Birmingham.
† Hill, Frederick	Park Street.
Hinds, William. M.D. (*P*) ..	Easy Row.
Hinds, James, M.B. (*C*) (*P*) ..	Halstead, Essex.
Hinks, T.	Buckingham Street.
Hobkirk, C. P. (*C*)	7, Arthur Street, Fitzwilliam Street, Huddersfield
Holbeche, R. A.	21, Bennett's Hill.
Hookham, George, M.A. ..	Trafalgar Road, Moseley.
Hookham, Philip	King's Norton.
Hooper, T.	Wylde Green.
Hopkins, A. N.	110, Bristol Road.
Houghton, F. T. S., B.A. ..	King Edward's School.
Howes, Henry	Bristol Street.
Hudson, R.	Lapworth, Hockley Heath.
Hughes, W. R., F.L.S. (*P*) ..	Wood House, Handsworth Wood.
Hughes, Mrs. W. R.	Wood House, Handsworth Wood.
Hutchinson, A. J.	126, Hockley Hill.
Huxley, T. H., LL.D., F.R.S., (*Hon. V.P.*)	4, Marlborough Place, St. John's Wood, N.W.
Huxley, Dr. J. C...	91, Harborne Road.
Impey, R. L.	Waterloo Street.
Innes, J.	Moseley.
James, Thomas	34, Worcester Street.
Jelf, John	Southbourne, Birchfield.
Johnson, Alfred	7, George Street, Parade.
Johnson, Miss	Packwood Grange, Knowle.
Johnstone, George Hope ..	Headingley, Hamstead, Handsworth.
Johnstone, William F.	24, Westminster Road.
Jones, George, M.R.C.S... ..	Newhall Street—41, Hagley Road.
Jones, H. W., F.C.S., F.R.M.S.	Princes Road.
Jones, T. Walter	Villa Road, Handsworth.
Jones, W. H.	St. Peter's Road, Handsworth.
Jones, W. H.	Stephenson Chambers, New Street.
Keep, J. S.	Park Road, Edgbaston.
Keeping, Professor W.	York Museum.
Kenrick, G. H.	Maple Bank, Church Road, Edgbaston.
Kent, W. Saville, F.L.S., F.R.M.S. (*C*)	Aston House, St. Stephen's Avenue, Shepherd's Bush, London, W.
Ketley, Charles	7, Belle Vue Terrace, Smethwick.

Ketley, Charles B.	7, Belle Vue Terrace, Smethwick.
Lancaster, W. J., F.C.S. ..	3, Snowdon Villa, Heathfield Road, Handsworth.
Latham, W. B.	Botanical Gardens.
Lauprecht, Madlle.	34, Frederick Road, Edgbaston.
Leigh, James	King's Norton.
†Levick, John	89, Lime Tree Villas, Albert Road.
Lloyd, R. M.	19, Spring Hill.
Lloyd, J., M.B.	Coventry Road.
Lloyd, J. H., B.A.	Edgbaston Grove, Church Road.
Lloyd, Wilson	Wednesbury.
Luckett, J.	Great Colmore Street.
Ludlow, W. R.	Sutton Lodge, Solihull.
Madeley, F.	Ox Hill, Handsworth.
Mapplebeck, John E., F.L.S. ..	Hartfield, Moseley Wake Green.
Marrian, J. R.	Longmore Street.
Marrian, Mrs. J. R.	Longmore Street.
Marris, Councillor	Bull Street.
†Marshall, W. P. *(P)*	15, Augustus Road.
Marshall, Mrs. W. P.	15, Augustus Road.
Marshall, Arthur M., D.Sc., B.A.	15, Augustus Road.
Martin, F. W.	Bournebrook Hall.
Martineau, Edgar	Solihull.
Mathews, Wm., M.A., F.G.S. ..	Harborne Road, Edgbaston.
Mathews, James	Hungary Hill, Stourbridge.
Mathews, Paul, M.A., F.C.S. ..	Hungary Hill, Stourbridge, and Newton College, South Devon.
Maw, George *(C)*	Benthall Hall, Broseley.
Mayo, Miss Beatrice	Elmshurst, Handsworth Wood.
Mayo, R.	Robert Road, Handsworth.
Merry, E.	Phœnix Works, Catherine St., Aston.
Middleton, Rev. G.	Bourne College, Summer Hill.
Miles, George	Vyse Street.
Miller, Herbert	12, Islington Row.
Mills, Arthur E.	73, Broad Street.
Mitchell, A. B.	40, Calthorpe Road, Edgbaston.
†Mitchell, F. W. V. *(L)*	212, Hagley Road, Edgbaston.
†Moore, C. W. B.	King's Norton.
Moore, W. G.	Scotland Passage, High Street.
†Morley, J.	Sherborne Road, Balsall Heath.
Morton, E.	Wilson Road, Birchfield.
Myers, Rev. E., F.G.S. *(C)* ..	Claremont Hill, Shrewsbury.
Naden, Thomas	14, Temple Street.

Nelson, William (*L*)	Freehold Street, York Road, Leeds.
Newton, R. A.	Newhall Street.
Norris, R., M.D.	Walsall Road, Birchfield.
Oliver, J. W.	271, St. Vincent Street.
Osborne, Alderman	Carpenter Road, Edgbaston.
Osler, Miss A.	South Bank, Harborne Road.
Owen, Lloyd	Newhall Street.
Painter, Rev. W. H. (*C*) ..	Park Villa, Knowle Road, Bristol.
Panton, G. A., F.R.S.E. ..	24, Bennett's Hill.
Parkes, W. E., M.D.	Soho Hill, Handsworth.
†Parsons, C. T.	Norfolk Road, Edgbaston.
Parsons, Mrs. C. T.	Norfolk Road, Edgbaston.
Parsons, Miss Mary	Norfolk Road, Edgbaston.
Parsons, Miss J. C.	Norfolk Road, Edgbaston.
Payton, Councillor H.	Eversley, Somerset Road.
Pearson, W. H.	50, Ann Street.
Pemberton, G. Arthur	21, Beaufort Road, Edgbaston.
Pendleton, W.	19, Northampton Street.
Percival, Exley (*C*)	Grassendale, Carlyle Road, Edgbaston.
Perrins, G. R.	South View, Cape Hill.
Phillips, Wm., F.L.S. (*C*) ..	Canonbury, Kingsland, Shrewsbury.
Phipson, A.	Metchley Lane, Harborne.
Pickering, J. W.	161, Belgrave Street.
Platten, Rev. H.	Monument House, Monument Road.
†Player, J. H., F.C.S.	31, Calthorpe Road.
Player, J., F.R.G.S.	Carpenter Road, Edgbaston.
Player, W. D.	19, Chad Road, Edgbaston.
†Pointon, A.	Temple Row.
†Pope, J.	King's Norton.
Potts, J.	Bennett's Hill.
President of the Royal Microscopical Society (*C*)	King's College, London.
†Pumphrey, C. (*L*)	King's Norton.
Pumphrey, J. H...	Regent Works, Herbert Road, Small Heath.
†Rabone, J...	Penderell House, Hamstead Road.
Rabone, Mrs. J.	Penderell House, Hamstead Road.
Randall, Rev. Wm., M.A. ..	Handsworth Rectory.
*Ratcliff, Charles, F.L.S. ..	Wyddrington, Edgbaston.
Reading, Alf.	13, Bennett's Hill.
Reynolds, E. J.	Beaufort Road, Edgbaston.
Richardson, W. E.	59, Varna Road.
Rickards, Dr. E.	96, Newhall Street.

Roberts, T. V.	.. .. ..	14, Alfred Road, Handsworth.
Robinson, E., M.D.	.. ..	9, George Road, Edgbaston.
Robinson, A. E.	.. .. ..	Milton Villa, Beech Lanes.
Robinson, C. R.	.. .. ..	25, Legge Lane, Graham Street.
Robison, R.	.. .. ..	Royal Insurance Co., Bennett's Hill.
†Roderick, John	.. .. ..	Hanbury Place, Rose Hill, Handsworth.
Rooke, W. ..	.. .. ..	Augusta Road, Moseley.
Rowlands, Joseph	.. ..	71, Colmore Row.
Russell, J., M.D. ..	.. ..	Newhall Street.
Ryland, Miss Susan	.. ..	16, Calthorpe Road, Edgbaston.
Ryland, W. P.	.. .. ..	Redlands, Erdington.
Schwarz, Dr.	.. .. ..	Queen's College.
Scruton, A.	.. .. ..	The Mount, Green Hill Road, Moseley.
Sharp, Councillor	.. ..	397, Bristol Street.
Sharpus, F. W. (*C*)	.. ..	30, Compton Road, Highbury, London.
Shoebotham, J. H.	.. ..	Highfield, Hermitage Rd., Edgbaston.
Short, R. M.	.. .. ..	Solihull.
Simcox, A...	.. .. ..	22, Cannon Street.
Simpson, E. (*C*) ..	.. ..	24, Grammont Road, Peckham Road, London, S.E.
Slatter, T. J., F.G.S.	.. ..	Bank, Evesham.
Slocombe, J.	.. .. ..	Grosvenor House, Hall Road, Handsworth.
Smedley, W. T., F.R.A.S.	..	57, Colmore Row.
Smith, T. H.	.. .. ..	Park Hill House, Hamstead.
Southall, H. W. ..	.. ..	Coppice Road, Moseley.
†Southall, William, F.L.S. (*P*)	..	Sir Harry's Road, Edgbaston.
Spencer, Herbert (*Hon. V.P.*)	..	38, Queen's Gardens, Kensington.
Spencer, J.	.. .. ..	Sandwell Villas, Birmingham Road, West Bromwich.
Spinks, W...	.. .. ..	Royal Nurseries, Harborne Road.
Stevens, Wm.	.. .. ..	Handsworth.
Stokes, W. H.	.. .. ..	Helvellyn, Birchfield.
Sturge, Joseph	.. .. ..	Wheeley's Road.
Sturge, Wilson	.. .. ..	Frederick Road, Edgbaston.
Symonds, Rev. W. S. (*C*)	..	Pendock Rectory, near Tewkesbury.
Tait, G. W., M.R.C.S. ..	..	Knowle.
† Tait, Lawson, F.R.C.S. (*P*)	..	7, Great Charles Street.
Tait, Mrs. Lawson	.. ..	7, Great Charles Street.
Tangye, G...	.. .. ..	Heathfield Hall, Handsworth.
Taunton, J. R. C.	.. ..	Sherborne Road.

Taylor, Reuben	Colmore Row.
Thomason, Geo.	Bennett's Hill.
Thomas, Dr. Wynne	Paradise Street.
Thomas, Howard	Great Hampton Street.
Thomas, Richard	Temple Row.
Till, W. S.	Hamstead Road, Handsworth,
†Timmins, Sam., J.P.	Elvetham Road, Edgbaston.
Timmins, Mrs. Sam.	Elvetham Road, Edgbaston.
†Tonks, Edmund, B.C.L. (*P*)	Packwood Grange, Knowle.
Toon, James	Pershore Road.
Turnbull, J. R.	43, Ann Street.
Turner, John	6, Stirling Road.
Twamley, C.	Ryton-on-Dunsmore, Coventry.
Twigg, G. H.	Summer Hill Terrace.
Tye, G. S.	62, Villa Road, Handsworth.
Tyerman, J. (*C*)	Penley, Tregoney, Cornwall.
Udall, J.	77, Summer Hill.
Underhill, F., M.R.C.S.	263, Moseley Road.
Vize, Rev. J. E., M.A. (*C.*)	Forden Vicarage, near Welshpool.
Wade, W. F., M.D.	Temple Row.
Wagstaff, E. H.	1, Waterworks Road, Edgbaston.
Walker, H. J.	Catherwell House, Stourbridge.
Waller, T. H., B.A., B.Sc, Lond.	71, Gough Road.
Walton, F. A.	Hamstead Road.
Warden, Chas., M.D.	31, Newhall Street.
Watson, C. J.	34, Smallbrook Street.
Webb, A. J.	St. Paul's Road, Moseley.
Welch, Dr. J. B.	Medical Officer of Health for Handsworth.
Welch, Dr.	Grammar School, Stourbridge.
Wells, S. J.	Tintern House, Handsworth.
White, Councillor W.	Sir Harry's Road, Edgbaston.
Whitfield, Hubert	5½, Broad Street.
Wilkins, Sylvanus	Forest House, Church Road, Moseley.
Wilkinson, Captain	Elmwood, Hamstead, Handsworth.
Wilkinson, Mrs., sen.	Ariston, Hamstead Road, Handsworth.
Wilkinson, Walter	Shobnall House, Handsworth Wood.
†Wilkinson, W. H.	Great Hampton Street.
Williams, D. J.	59, New Street.
Williams, S. D., jun.	Easy Row.
Willis, W. (*C*)	49, Palace Grove, Bromley, Kent.
Willis, John	1, Calthorpe Road, Edgbaston.
Willmore, F. W.	The Willows, Walsall.

†Wills, A. W. (P)	Claregate, Wylde Green, Erdington.
Wills, Mrs. A. W.	Claregate, Wylde Green, Erdington.
Wills, Miss L. E.	Claregate, Wylde Green, Erdington.
Wilson, J.	Acocks Green.
Wilson, J. A.	Edgbaston.
Wilson, Wright, F.R.C.S. Edin., F.L.S.	21, Crescent.
Withers, F.	Rope Walk, Farm Street.
Woodfield, Dr. T. R. V.	Acocks Green.
Woodman, W.	Trafalgar Road, Moseley.
Woodward, C. J., B.Sc., F.G.S.	79, Harborne Road.
Wright, J. H.	Malvern Villas, Soho Hill.
Wright, Mrs. J. H.	Malvern Villas, Soho Hill.
Wright, Richard (C)	Royal Insurance, Manchester.
Wright, M. Hall	The Hollies, Summer Hill.
Wrighton, Alfred..	60, Summer Hill.
Wynn, J. C.	Court Oak Road, Harborne.
Wynne, W. P.	Hasluck's Green, Shirley.
Yeoman, W. C.	Park Villa, Solihull.

ASSOCIATES.

AGE.		
16	Allport, Frank	Colmore Row.
19	Chapman, J. H.	172, Stratford Road.
15	Dammann, J. F. R... ..	22, Francis Road.
18	Devis, H. F.	Laurel Cottage, King's Heath.
17	Dunn, S.	97, Camden Street.
17	Hewitt, F. E.	Woodlands Road, Smethwick.
16	Johnstone, F. W.	24, Westminster Road.
15	Saunders, J. V.	137, Birchfield Road.
15	Stone, H.	Cavendish House, Grosvenor Road, Handsworth.
16	Wynne, A. E.	King Edward's School.

The Treasurer in Account with the Birmingham Natural History and Microscopical Society.

Dr.

1880.	£ s. d.	£ s. d.
Jan. 1.—To Balance of General account ..	33 19 7½	
" Apparatus account ...	12 12 6	
		46 12 1½
" Subscriptions—		
For 1877-78-79 ...	24 2 6	
" 1880 ...	117 5 6	
" 1881 ...	6 0 0	
" Life ...	10 10 0	
" Apparatus ...	18 12 0	
		176 10 0
" Members' Donations to Free Library Restoration ...		10 10 0
Receipts at Soirée ...		66 15 4
		£300 7 5½

Examined and found correct,

January 31st, 1881,

JOHN EDMUNDS.

J. W. PICKERING.

Cr.

1880.	£ s. d.	£ s. d.
Jan. 1.—By Books and Binding ...		57 1 6
" Apparatus, viz.:—		
Swift Microscope ..	23 9 0	
Crouch "	27 1 0	
Turntables ...	6 16 9	
One pair Ross Eye Pieces	1 16 6	
Engraving ...	0 13 0	
		59 16 3
" Printing Reports ...	12 6 6	
" " Catalogues and Laws ...	10 13 2½	
" " Programmes, &c. ...	12 19 2	
" " Illustrations for Reports	2 9 11	
" " " for Naturalist	5 12 3	
" " " for Papers ...	0 1 7	
		44 5 7½
" Postage and Sundries—		
Per Hon. Secretaries ...	18 12 10½	
" Hon. Treasurer ...	1 8 7	
" Hon. Librarian ...	0 17 0	
" Curators ...	0 12 6	
" Excursions ...	2 10 6	
		24 1 5½
" Midland Union of Natural History Society Subscriptions...	3 17 6	
" Sundry Postage, &c. ...	0 14 0	
		4 11 6
" Soirée Expenses ...		73 10 3
" Rent, Insurance, and Repairs ...		5 1 6
" Stereotyping for Cryptogamic Flora		1 13 0
" Free Library Restoration Fund ...		10 10 0
" Balance Cash in hand carried forward		19 13 4½
		£300 7 5½

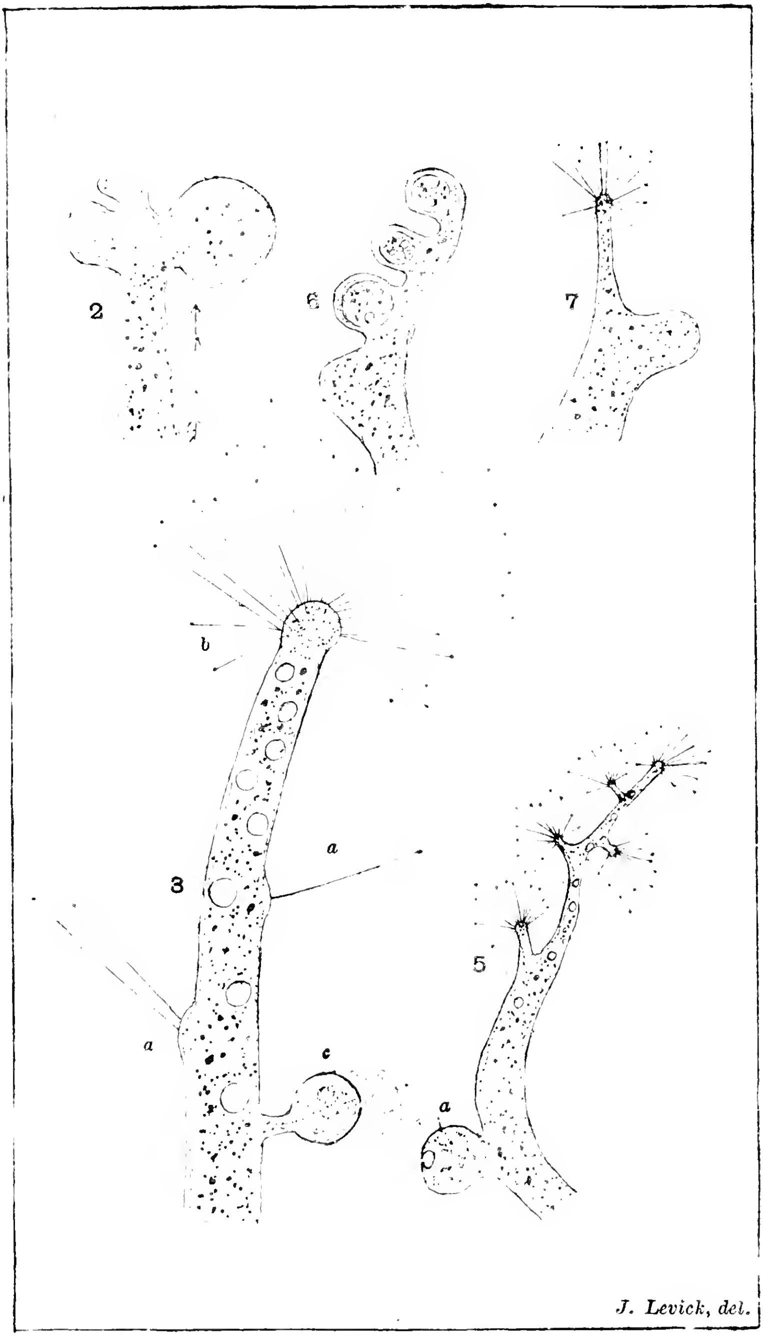
Birmingham Natural History and Microscopical Society.

LIST OF OFFICERS FROM 1864 TO 1881 INCLUSIVE.

*** *THE BIRMINGHAM NATURAL HISTORY ASSOCIATION was founded in* 1858, *and was reconstructed in the year* 1864, *under the present title.*

	PRESIDENT.	VICE-PRESIDENTS.	TREASURER	SECRETARY.	LIBRARIAN.	CURATORS.
1864	W. R. Hughes, F.L.S.	William Willis Thomas Fiddian	George Heaton	Charles Adcock	A. E. Fardon	C. J. Woodward.
1865	W. R. Hughes, F.L.S.	Thomas Fiddian L. Percival	George Heaton	James Hinds, M.B.	Thomas Scott	E. J. Chitty.
1866	W. R. Hughes, F.L.S.	Thomas Fiddian L. Percival	George Heaton	Thomas Jephcott	Thomas Scott	E. J. Chitty.
1867	Jas. Hinds, M.B.	C. T. Parsons W. P. Marshall, C.E.	George Heaton	Thomas Jephcott	Thomas Scott	Fras. Fowke.
1868	Samuel Allport, F.G.S.	W. P. Marshall, C.E. W. Mathews, jun., M.A.	George Heaton	A. W. Wills	George Crofts	Fras. Fowke.
1869	W. P. Marshall, C.E.	William Hinds, M.D. Edward Myers, F.G.S.	George Heaton	A. W. Wills	George Crofts	James E. Bagnall.
1870	William Hinds, M.D.	Edward Myers, F.G.S. A. W. Wills	Charles Pumphrey	Edward Simpson	James E. Bagnall	W. B. Latham. John Morley.
1871	A. W. Wills	J. W. Cotton, F.G.S. Rev. H. W. Crosskey, F.G.S.	Charles Pumphrey	W. G. Blatch	John Morley	James E. Bagnall. G. Sherriff Tye.
1872	Rev. H. W. Crosskey, F.G.S.	Jas. E. Bagnall Rev. G. Deane, D.Sc	Charles Pumphrey	W. G. Blatch	John Morley	R. M. Lloyd. G. Sherriff Tye.
1873	W. R. Hughes, F.L.S.	Rev. H. W. Crosskey, F.G.S. Rev. G. Deane, D.Sc.	Charles Pumphrey	W. G. Blatch	John Morley	R. M. Lloyd. W. Nelson.
1874	Rev. G. Deane, D.Sc., F.G.S.	Edmund Tonks, B.C.L. John Morley	Charles Pumphrey	W. Wright Wilson, F.L.S.	James E. Bagnall.	J. W. Cotton, F.G.S. Thomas Fiddian.
1875	A. W. Wills	John Morley Lawson Tait	Charles Pumphrey	W. Wright Wilson, F.L.S.	James E. Bagnall.	J. W. Cotton, F.G.S. G. Sherriff Tye.
1876	Lawson Tait, F.R.C.S.	Walter Graham Edmund Tonks, B.C.L.	Charles Pumphrey	C. B. Caswell John Morley	James E. Bagnall.	G. Sherriff Tye. G. Edmonds.
1877	Edmund Tonks, B.C.L.	Walter Graham G. Sherriff Tye	Charles Pumphrey	John Morley	James E. Bagnall.	John Levick. W. H. Cox.
1878	Edmund Tonks, B.C.L.	Walter Graham E. W. Badger	Charles Pumphrey	John Morley	James E. Bagnall.	John Levick. W. H. Cox.
1879	W. Graham, F.R.M.S.	E. W. Badger W. Southall, F.L.S.	Charles Pumphrey	John Morley H. E. Forrest	James E. Bagnall.	John Levick. W. H. Cox.
1880	W. Southall, F.L.S., F.R.M.S.	E. W. Badger John Levick	Charles Pumphrey	John Morley H. E. Forrest, F.R.M.S.	James E. Bagnall.	W. B. Grove, B.A. R. M. Lloyd.
1881	Edward W. Badger	John Levick T. H. Waller	Charles Pumphrey	John Morley W. B. Grove, B.A.	James E. Bagnall.	R. M. Lloyd. H. W. Jones, F.C.S.

Plate I.



Dendrosoma radians.

DENDROSOMA RADIANS.

BY J. LEVICK.

Read before the Society December 16, 1879.

In bringing under your notice *Dendrosoma radians*, I cannot claim for it the beauty of colour, form, and motion, of those tiny spheres of revolving vegetable life known to us all as *Volvox globator;* nor do I promise you that pleasure which most microscopists feel in watching the delicate ciliary action and tracing the wonderful internal organisation of the Rotifera or Polyzoa. But I can recommend it as an object worthy of careful observation, gaining in interest the more perfectly its life-history is made out, and one that serves, perhaps better than any other, to give a general idea of a curious family of microscopic creatures, the Acinetina, of which many forms have been exhibited at our meetings, and of which specimens of one kind or other are to be found in nearly every pond and stream. From some cause or other, this organism seems to have escaped that careful study, given to many of its allies, which is necessary to make out its economy and life-history. Whether this arises from the rarity of its occurrence, the difficulty of observation, or its apparent lack of interest, I am unable to say, but I have felt, as have probably many others, that the descriptions in the books we have at our command are meagre and unsatisfactory, and, as far as I have been able to observe, often incorrect, no figure even being given in any English work.

In the case of Dendrosoma, as in that of a large proportion of the known microscopic forms of animal and vegetable life, Ehrenberg appears to have been the first to note and record its existence. Subsequently, Stein and others have given it more or less attention, but with the result that it is still left in an uncertain position, no satisfactory conclusion having been arrived at as to whether it is a real species or a mere stage in the development of some other Infusorian, as Vorticella or Vaginicola. In fact, the whole genus of Acineta is scarcely free from a similar doubt in the minds of some observers, although

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REFERENCES TO PLATES I. AND II.

Fig. 1.—Dendrosoma, a fine specimen, × 50 diameters.
Fig. 2.— „ moving as an Amœba, × 100 diameters.
Fig. 3.— „ with testes and early stages of the tentaculated heads, × 220 diameters
Fig. 4.— „ showing embryos, × 220 diameters.
Fig. 5.— „ showing ovary, × 100 diameters.
Fig. 6.— „ a much contracted form, with three probable embryos × 220 diameters.
Fig. 7.— „ supposed further stage of the series, 4A—4D, × 220 diameters.
Figs. E and F.—Part of Fig. 4, showing gradual return of the parent to normal form, × 440 diameters.
Fig. G.—Probable egg, × 440 diameters.

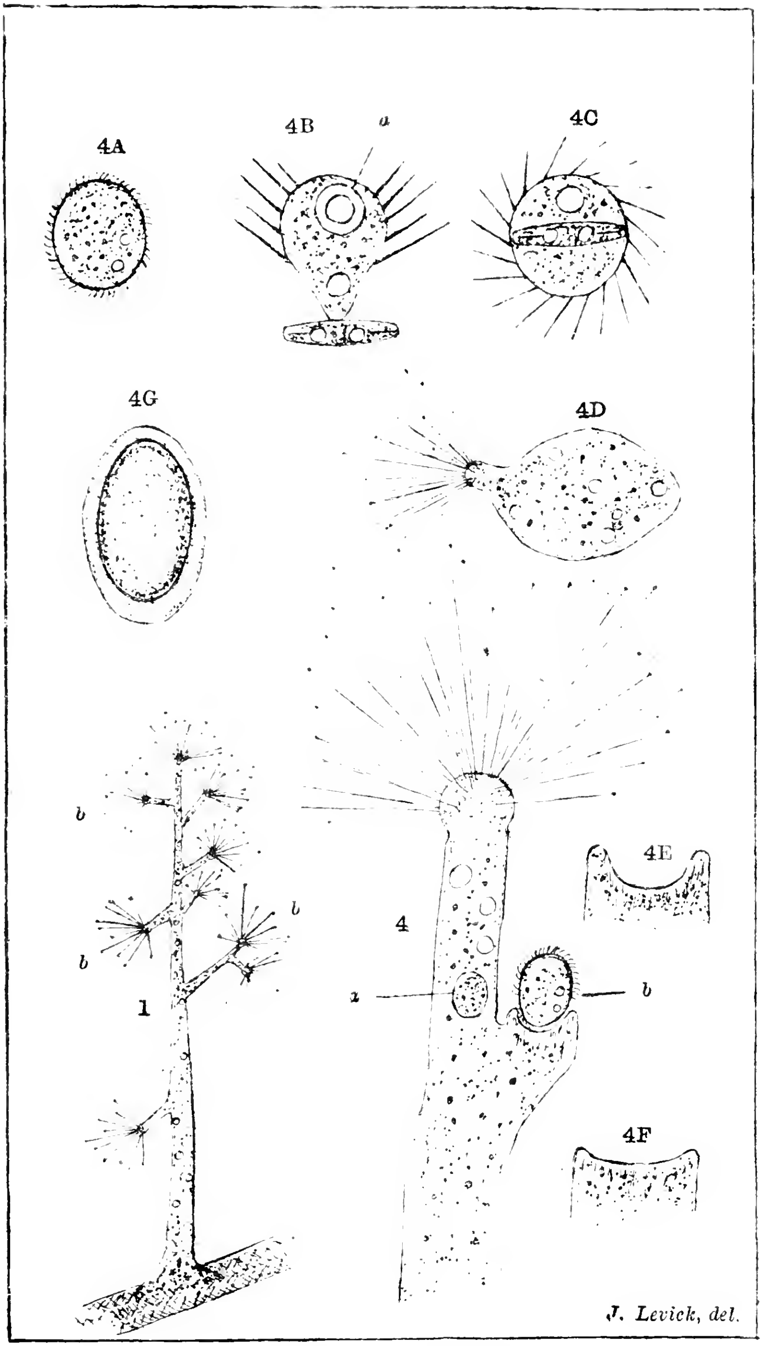
Stein, with whom this strange theory originated, long ago gave it up. It is even suggested that Dendrosoma may be an Actinophrys, or an Anthophysa.

The name Dendrosoma, from the Greek δένδρον a tree, and σῶμα a body, fairly expresses the idea generally entertained as to the character of this creature, (Plate II., Fig. 1,) each of the tentaculated prominences being set down as an animalcule joined to a common stalk or pedicle, the whole forming, as Perty described it, an aggregated Actinophrys, in which individuals are collected into a colony; reproduction was supposed to take place by gemmation, a process familiar to us in the common Hydra. This recalls to my mind a well-worn illustration, for which, it is said, we are indebted to Buffon. He pointed out to the lexicographers that their description of a crab as "a little red fish which runs backwards," was wrong in just three particulars, namely, that it was not a fish, that its colour was not red, and that it did not run backwards. I think that a similarly radical criticism might be applied to the usual description of Dendrosoma, for, in the first place, it is one individual, and not a colony; in the second, it is an Acineta, and not an Actinophrys; and, in the third, the process of budding does not appear to be one of its modes of reproduction.

Its size, which varies considerably, is stated in the Micrographic Dictionary as 1-96th of an inch in length, but this is much under the mark, as I have measured specimens as long as 1-15th of an inch, or more than six times the published measurement. Seen in the microscope, with a fairly high power, it has a tree-like stem, generally covered with foreign matter, which adheres to its viscous surface, and, for this reason, it is difficult to see through the object with sufficient clearness to make out its structure. The whole of the pedicle, when rendered perfectly clean, is highly transparent, and is seen to be full of granules and contractile vesicles, the former differing greatly in size, and the latter so numerous that, in a starved specimen I had under observation, they might have been fitly compared to marbles in a bag. These granules, which are neither more nor less than particles of food after ingestion, are seen to be in active circulation. The currents appear to be four, two upwards and two downwards, but of course are really only half that number, as they make a double circuit of the whole creature; reminding one of the motion of the sap in Chara or Nitella, only that in each cell of those plants there is one continuous stream instead of two.

At irregular intervals, not alternate as generally stated, the stem branches out into somewhat rounded bud-like heads, the form of which the creature is able to modify greatly. From these it extends a variable number of extremely fine tentacles, each of which has a little knob at the end, or is, to speak technically, capitate. The heads or buds are first seen as slight swellings of the pedicle, with perhaps one or two tentacles (Fig. 3*a*.) Sometimes they continue enlarging, and ultimately arrive at the normal stage, (Fig, 3*b*,) but are often again withdrawn, leaving no indication of their previous existence.

Plate II.



Dendrosoma radians.

The next point investigated was the manner in which the so-called buds were attached to the pedicle, and whether they were destined to become new individuals, or remain as temporary or permanent features of the creature. I had never found one in which I could trace the least indication of the constriction which usually precedes separation, as observed in the process of gemmation in the Hydra, or fission in the Infusoria. I at length satisfied myself that the so-called buds are nothing of the kind, being really extensions of the stem, which the animal is able to produce *ad libitum*, and as readily withdraw again as before described. Probably when plenty of food is present, or the creature is sluggish in action, few of these processes are thrown out, but when the minute animalcules on which it feeds are scarce, or great activity prevails, as before the process of multiplication, many of these heads are necessary for fitting it to perform its functions.

I then sought to ascertain the way in which food is taken in, because that is perhaps the best general distinction between the Acineta and the Actinophrys; and as some may not be familiar with the mode in which this Rhizopod accomplishes this important part of its work, I will briefly describe it. The Actinophrys attacks its prey, consisting of living animalcules, by its lance-shaped tentacles, which, in common species, radiate in every direction, and, being furnished with a sticky secretion, and possibly also possessing an urticating power, seize it and draw it down to the surface of the body. Part of the tentacles are withdrawn to allow of this, and the captured prey appears, so to speak, to melt its way into the creature, just as a stone will melt its way into ice when the sun shines upon it. The food of the Actinophrys usually passes on towards the centre of the body, where it is absorbed.

In Dendrosoma the process is different. The food, which also consists of Infusoria, only more minute, is indeed captured by the tentacles, but instead of being brought down to the body is held, if I may so express it, at arm's length, and, as it appears under a low power, is most mysteriously passed into the stem of the creature by their aid alone; only the more solid parts of the prey remain, which always fall to pieces in the end. Thus these delicate organs perform a feat of dissection far beyond the power of microscopists to imitate. A higher power, however, proves that the tentacles, notwithstanding their extreme tenuity, are tubes capped by a suctorial arrangement, capable not only of seizing and holding their captives and resisting their struggles, but of piercing their ectoderm, and, at the same time shortening and thickening, of absorbing all the gelatinous part and small granules into the pedicle, which is, in fact, the stomach of the creature. It sometimes happens that two Dendrosomata will feed upon one animacule, like two chickens at a worm, but it more frequently occurs that many Infusoria are being ingested at the same time by one Dendrosoma, all the heads being actively engaged; to quote Wordsworth's line,

"Forty feeding like one."

Effete matter appears to escape from the organism at the base of the tentacula, where it is frequently seen collected, and possibly passes out through those organs, while greatly contracted.

Whether, like the Hydra or Actinophrys, these creatures have any stinging power, I have not yet satisfied myself; but once, whilst examining one, I saw a Rotifer, *Pterodina patina*, allow its cilia to come in contact with the tentacles of the Dendrosoma, whereupon it sharply withdrew its ciliary wreath, and shut itself up within its lorica, as if it had been burnt, nor did it venture to put them out again during the two or three hours it was under my notice. This shows that at all events Rotifers do not regard Dendrosomata as desirable company.

The fact of the food being absorbed by means of suctorial tentacles admits of the animal having a firm outer integument, entirely different from that of Actinophrys or Amœba, which pass their prey through their bodies; but, notwithstanding its rigid appearance and probable firmness of texture, it is able to vary its form in a remarkable manner, and one which I saw pouring itself from one point to another, after the style of an Amœba, is sketched at Fig. 2. The arrows show the direction of motion. All its contents appeared to be passing into the bulbs at the end, which were rapidly enlarging, while the other part of the creature was as quickly becoming less. Mr. H. E. Forrest was with me when this took place, and the change occupied so short a time, and was so similar to that of an Amœba, that the metamorphosed Dendrosoma might easily have been mistaken for one. I may point out here that though the pseudopodial processes, with which Dendrosoma and its allies are armed, are described as tentacles, being used for prehensile purposes, they differ from those of the Hydra, Actinophrys, and, indeed, all other tentacles with which I am acquainted, in the fact that each is a perfect tube, and is furnished by a suctorial arrangement which serves the purpose of a mouth. This feature distinguishes the Acinetina from their allies, forming one of Huxley's convenient divisions of the Infusoria, namely, the Tentaculifera, (the others being the Flagellata and the Ciliata,) though I do not suppose that it invariably holds good, most sharp lines in nature breaking down somewhere.

I next noticed the modes of reproduction, of which, as before stated, Perty only mentions that of budding, meaning, no doubt, that the tentaculated heads (Fig. 1*b*) detach themselves when mature, and form each a new Dendrosoma. But I could never trace the least signs of a probable separation, as I have previously remarked, each so-called bud always retaining a perfect tubular connection with the stem. Instead of this, I found what I at first thought was a very large ingested Infusorian. This, which I have drawn at Fig. 4*a*, proved to be a growing embryo. I watched it very carefully, until it made its escape in the manner shown at *b*, where it is seen to be ciliated. I afterwards traced it through the various phases indicated at Figs. 4A, 4B, 4C, and finally saw it approach the parent form as shown at 4D. This process, I feel satisfied, is an asexual mode of reproduction, agreeing as it does with a recognised manner of multiplication in the Acineta, namely, by free embryos, which at this stage were supposed by some observers to pass into their "perfect" conditions as Vorticellæ, Vaginicolæ, &c., though the "perfect" condition of Dendrosoma in particular seems not to have been fixed upon.

In the adult form I have not positively recognised a nucleus, being unable to treat my specimens with reagents, as I could not separate the group under observation without spoiling it, but in the free embryos what at first appeared as a second vesicle proved to be a nucleus and nucleolus, (Fig 4B*a*.)

A curious feature of these free ciliated embryos was that, after swimming about in a purposeless manner for a time, they settled down, attaching themselves to anything near; the cilia then gave place to pseudopodia, much like those of an Actinophrys, which in the one sketched at Fig. C were ranged nearly at a tangent. This embryo (Fig. 4B) anchored itself to a diatom equal in length to its own diameter, and afterwards ingested it as an Actinophrys or Amœba would. Figs. 4E and 4F show the gradual return of the parent Dendrosoma to the normal form, after the escape of the embryo.

It is somewhat singular that, though conjugation is set down by one or two observers as common in the Acinetæ, I have never seen it, although I have made special search for it; but in two Dendrosomata I saw what may possibly have been an attempt in that direction, when they evidently modified their shape for some purpose or other, though in such a manner that I could not decide whether one was merely moving out of the way of the other, or trying to swallow it.

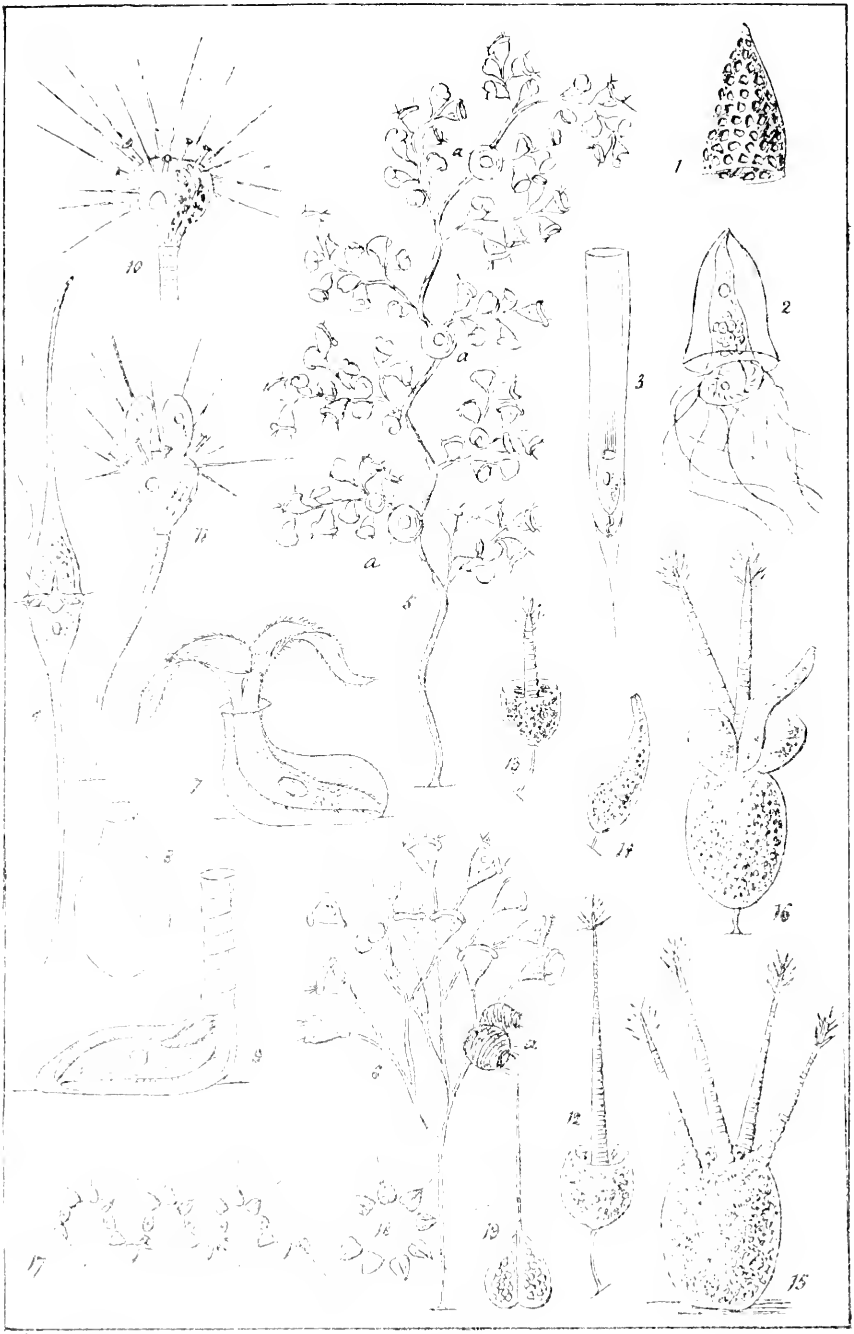
The same group of specimens which had now been under frequent and sometimes protracted observation for eight weeks furnished me with two specimens, showing what were evidently the true sperm and germ elements, these features occurring on two separate individuals in close proximity to each other, (Figs. 3*c*, 5*a*.) They bore so much resemblance to the testes and ovary of the Hydra that I felt no doubt whatever of their function from the first, though I had never seen the phenomenon before in Dendrosoma, and was not aware of its having been noted in this or any other form of the Acinetina. After a little patient watching, I was rewarded by seeing the spermatozoa, not only in active motion within the sperm cell, but also escaping freely into the surrounding water, (Fig. 3*c*.) At the same time the ovary on the other individual, which at first showed only a slight circular mark, had now a decided opening, (Fig. 5*a* ;) though I could not positively trace the contact of the fertilising agents with the germ, the process was so conclusive as to leave no doubt of its meaning on my mind.

I was now anxious to discover, if possible, the result of this phenomenon; and, having become so familiar with Dendrosoma in a great variety of forms, and my specimens being isolated, I had not much difficulty in recognising the form sketched in Fig. 4G as the probable egg. The before-mentioned embryos and this germ had the same histological characters as well as the common distinguishing feature of being full of granules, which are destined, no doubt, to serve as food, until the young are able to feed themselves. This egg differed from the free embryos in having no cilia ; it was larger, more oblong in form, and bore some resemblauce to an exceedingly minute statoblast of some freshwater Polyzoon, but its colour was very different, being dirty-white, the same as that of the parent. It was furnished with a comparatively rigid case or shell, and would, doubtless, remain in a state of rest during the winter. When these develope in spring or summer, they must necessarily appear as free ciliated organisms for a time, until they find a suitable place to which to attach themselves, and become stationary or approximately so. I say, approximately, because I think they are able to change their position slightly without detaching themselves.

I have now only to point out that the study of this creature has fully satisfied me that it is a real species, its branched character giving it even generic importance. It is not a developmental stage of something else, being able to reproduce its kind in two distinct ways at least, and the imperfect history here recorded goes entirely against the theory propounded by Prof. Stein, and supported by Balbiani, that the Acinetæ are only a phase in the life cycle of various species of Infusoria. This mistake appears to have arisen from the fact that these animals, being provided with suctorial tentacles, are enabled to adhere to their prey, and were regarded as a stage in the life-history of the creature to which they were attached, when they should have been looked upon rather in the light of parasites.

Fig. 6 is a fine Dendrosoma much contracted, and entirely without heads or tentacles. It contained what I believed to be three embryos, but remained in a state of inactivity, showing no further change. Fig. 7 is probably a more advanced stage in the series 4A, 4B, 4C, and 4D, but, as I did not succeed in following it up to this point, I have merely sketched it as seen. I ought also to mention that I have indicated the commencement of the heads on the same creature as the one drawn with the testes, to save another figure, but they were really observed on distinct individuals. The specimen with the sperm cell had only one well developed head, with its tentacles radiating in all directions.

Plate IV.



W. Saville Kent del.

Marine Infusoria.

NOTES ON MARINE INFUSORIA.*

BY W. SAVILLE KENT, F.L.S., F.R.M.S., ETC.

Read before the Society January 20th, 1880.

Among the treasure trove amassed by the Birmingham Natural History Society during their last summer's enjoyable outing on the Cornish coast, and at the gathering of which said material, availing myself of the kind invitation of the President, Mr. Walter Graham, I was permitted to assist, a considerable number and variety of Marine Infusoria were obtained. While none of these are new to science, several of them possess a more than ordinary interest with relation in some cases to their individual plan of structure and affinities, and in others to their marked diversity from the Infusorial types more frequently encountered by non-migratory "Midland Naturalists." To some few of these minute organisms, the produce of one day's wielding of the dredge and towing net, (July 11th,) I here propose to direct attention, accompanying my remarks with delineations of the more important forms.

Out of the eight types in all it is here proposed to select, the majority, five in number, were found associated with the horny

References to Plate IV.

Fig. 1.—*Dictyocysta cassis*, empty siliceous lorica, showing fenestrated pattern.

Fig. 2.—*Dictyocysta cassis*, animalcule with extended tenticula; the fenestræ of the lorica are not represented, in order to give a clear view of the occupant (after Hæckel)

Fig. 3.—*Tintinnus subulatus.*

Fig. 4.—*Ceratium fusus.*

Fig. 5.—*Zoothamnium alternans*, showing at a, a, a, the larger and axillary reproductive zooids.

Fig. 6.—*Zoothamnium dichotomum*, showing at a, a, a, the larger transversely-striate reproductive Zooids.

Fig. 7.—*Follicularia ampulla*, animalcule extended and inhabiting a lorica, with a moderately-produced neck=*Lagotia viridis*, S. Wright.

Fig. 8.—*Follicularia ampulla*, empty lorica, with very short neck.

Fig. 9.—*Follicularia ampulla*, lorica, with greatly produced neck, exhibiting annular growth markings; *Lagotia producta*, S. Wright.

Fig. 10.—*Hemiophrya gemmipara*, with tentacles of two orders fully extended.

Fig. 11.—*Hemiophrya gemmipara*, with two anteriorly developed buds.

Fig. 12.—*Ophryodendron pedicillatum*, proboscidiform zooid, with characteristic organ extended.

Fig. 13.—*Ophryodendron pedicillatum*, with proboscis retracted.

Fig. 14.—*Ophryodendron pedicillatum*, vermiform zooid.

Fig. 15.—*Ophryodendron multicapitatum*, sessile zooid, with four proboscidiform appendages.

Fig. 16.—*Ophryodendron multicapitatum*, stalked zooid, with two probosci liform organs, one immaturely developed vermiform zooid, and two supplementary spheroidal buds.

Fig. 17.—*Asterionella Bleakeleyii* (?) showing characteristic spiral disposition of the associated frustules.

Fig. 18.—*Asterionella Bleakeleyii* (?) a few detached frustules, exhibiting a substellate disposition.

Fig. 19.—*Asterionella Bleakeleyii*, single frustule.

* The full title of this paper is "Notes on Certain Marine Infusoria, obtained during the Summer Excursion (1879) to Falmouth of the Birmingham Natural History and Microscopical Society, communicated by W. Saville Kent, F.L.S., F.R.M.S., and Honorary Corresponding Member of the Birmingham Natural History and Microscopical Society."

polypidoms of the Hydroid Zoophytes, Polyzoa, and other organic matter brought by the dredge from the sea-bottom. By the use of the towing-net, employed, however, on one occasion only, and when the elements were by no means propitious for such operations, the small minority, including, as it eventually proved, the most interesting capture of the series, was secured. The contents of the net, as emptied on board the steam-boat into the glass receivers, were by no means promising, consisting merely of a little flocculent matter, at first distributed indifferently through the mass of water, but which, after a short interval, collected at the surface in the form of a pale yellow unsubstantial scum. Specimens of this scum examined fresh, and permanently mounted, both on board and later on in the evening, on our return to Falmouth, demonstrated that almost its entire mass was composed of two minute pelagic diatomaceous types. One of these, (Plate IV., Figs. 17 to 19,) forming substellate or long spiral and corkscrew-like aggregations, each component frustule having a somewhat inflated triangular body, and a long median and spine-like apical prolongation, is apparently identical with, or closely allied to, *Asterionella Bleakeleyii*. In no account of the several species of this same genus, at this moment accessible, however, do I find any record of their formation of long symmetrically twisted spiral aggregations, which in the present case is so eminently characteristic of the fully developed and perfect organism. The second, but less dominant diatomaceous type, accords essentially with the figures and descriptions given of *Rhizosolenia setigera*, consisting of perfectly straight, attenuate cylindrical frustules, chiefly remarkable for their finely produced and needle-like axial terminations. In some of the larger frustules a single or double spiral pattern was faintly discernible.

A more leisurely examination of the mounted slides of these diatomaceous skimmings has led to the detection among the same of the three infusorial forms placed first on this list. All these are, like the diatoms, essentially pelagic in their habits, and, possessing in each case an indurated lorica or carapace, adapt themselves readily for permanent preservation.

1.—*Dictyocysta cassis*, Hkl., (Plate IV., Figs. 1 and 2.)—Of this type, the most interesting capture on my list, unfortunately only the empty test or lorica has been preserved. The form and structure of this skeletal element are, however, so definite and characteristic as to leave no doubt whatever regarding the nature and relations of its former occupant. The lorica, which resembles in shape a conical cap or helmet, is of silicious consistence, perforated throughout with closely-set, irregular, polygonal foramina, and, in the absence of the knowledge that has recently come to hand, would be regarded as the silicious test of one of the simpler pelagic Radiolaria, and be referred in that same group to Ehrenberg's Polycystine genus, *Dictyocysta*. Professor Hæckel, however, has lately shown in an account of some new pelagic Infusoria, published in the "Jenaische Zeitschrift," for the year 1873, that the original fabricators and inhabitants of these elegant helmet-shaped tests are not Radiolaria, but belong to the more highly organised group of the Ciliate Infusoria, representing among the same a specially modified form of the Vorticellidæ and other familiar members of the section Peritricha. The test itself, except for its silicious consistence and cancellated structure, corresponds morphologically and physiologically with the horny or chitinous protective lorica of a *Cothurnia* or *Vaginicola*. It is a secretion or exudation of the external cuticula. The enclosed animalcule, however, as shown by Hæckel, exhibits a very wide divergence from the ordinary Peritrichous type. The body of the same is attached posteriorly to the proximal or hinder extremity of the cavity of the lorica, while the more expanded oral or distal region is projected, when the animalcule is extended, beyond its everted anterior margin so far that the *tout ensemble* may be compared to a minute bell, in which case the lorica represents the bell-body, and the posteriorly attached animalcule the clapper. It is in the projecting oral region of the animalcule that the essential points of modification are found to obtain. Here, in place of the customary simply circular or spiral wreath of cilia, the margins of the oral disc are produced into about twenty long tentacle-like organs, probably of a prehensile nature, which, as the animalcule swims mouth downwards through the water, impart to it the aspect of a minute jelly fish or medusa. Inside the outer wreath of tentacles, which would appear to represent outgrowths or prolongations of the raised peristome-border of an ordinary *Vorticella*, is situated an inner circlet of stout vibratile cilia, which conducts to the oral aperture. This is apparently homologous with the adoral ciliary wreath of the same peritrichous type. *Dictyocysta cassis*, with which the minute silicious lorica taken in the towing-net on the Cornish coast entirely corresponds, was originally discovered by Professor Hæckel, in the neighbourhood of Messina, and its recent encounter in so much more northerly a latitude is of itself a feature of considerable interest. Three other species of *Dictyocysta*, all distinguished by various modifications of the form of the lorica, or in the pattern of its perforations, were obtained by Professor Hæckel from the same Mediterranean station, which would appear to lie within its most congenial and favoured area of geographical distribution. Two remaining species, upon which, in the year 1854, the genus was first founded by Ehrenberg, were encountered in deep Atlantic soundings, and no doubt originally lived, like Noctiluca and the Radiolaria, in the surface waters. Three infusorial types, having tentacle-like appendages, similar to those of *Dictyocysta*, but with loricæ formed of chitine, with an admixture of agglutinated sand grains and other foreign particles, have been described by Professor Hæckel. in the serial above quoted, in association with the new generic title of *Codonella*. The delineation here given of the animalcule of *Dictyocysta cassis* is reproduced from Hæckel's illustrations, that of the lorica being a sketch from the Falmouth specimen.

2.—*Tintinnus subulatus*, Müller, (Plate IV., Fig. 3.)—A single example this type has been found mixed with the preserved diatomaceous skimmings. The lorica is of glass-like transparency, sub-cylindrical, and produced at the proximal or posterior extremity into an acute and often much attenuated spine-like point; it bears, in fact, no inconsiderable resemblance to the segment of a frustule of the diatom, *Rhizosolenia setigera*, with which it is so abundantly associated. The contained animalcule, resembling an elongate *Vorticella*, is fixed by a contractile pedicle to the bottom, or sometimes to one side of the lorica, and does not project beyond its anterior margin. The oral cilia, forming a spiral wreath at the distal extremity, are exceedingly long and powerful, and in its normally free-swimming state serve to propel the animalcule and its associated lorica backwards through the water with great rapidity. According to Claperède and Lachmann, the entire body in the representatives of this same genus is clothed throughout with fine vibratile cilia, and thus assimilates the typical characteristics of the section Heterotricha; the presence of these finer cilia, however, could not be detected in the spirit-preserved example recently examined.

3.—*Ceratium fusus*, Ehr., (Plate IV., Fig. 4.)—Several examples of this cilio-flagellate type have been found scattered through the prepared slides referred to, this species being remarkable among its associated family group of the Peridiniidæ on account of the production of the two segments of the carapace into single attenuate axial prolongations, the other representatives of the same genus, as *C. tripos* and *C. furca*, having usually two antero-lateral and not axially disposed processes. Although *Ceratium* is usually regarded as an essentially marine type, one form, *C. Kumaonense*, has been described by Mr. Carter (Ann. Nat. Hist., Vol. VII., 1871,) as occurring in prodigious numbers in the lakes of Kumaon, Hindostan, at an elevation of from 4,000ft. to 6,500ft. above the sea level, while the *Ceratium (Peridinium) longicorne* of Perty, (having, like *C. Kumaonense*, three anterior horn-like prolongations,) originally found in Switzerland, has been recently encountered in the neighbourhood of Birmingham, whence I have received specimens for identification from the hands of Mr. Levick. Among the Falmouth specimens of *Ceratium fusus*, one example in which the carapace had been crushed, and the enclosed yellowish and granular protoplasm extruded, exhibited a well marked oval nucleus-like body, while the aspect of the fractured edges of the carapace seemed entirely to support the suggestion recently made to me by Mr. Charles Stewart, F.L.S., and arrived at by his burning *C. tripos* on platinum over a spirit lamp without the destruction of the carapace, that this latter, in the case at least of the marine types, is probably of a silicious nature. The animalcule of *Ceratium* corresponds essentially with that of *Peridinium*, having a monadiform structure, and single long lash-like flagellum, which projects from a medially situated oval aperture; the carapace consists of an anterior and posterior valve, closely approximated, with an equatorial groove or channel between them upon which a circlet of fine vibratile cilia is developed, and upon the ventral face of which groove the oral aperture with its associated lash-like flagellum debouches. The fresh-water *Peridinium tabulatum* recently supplied to me from the neighbourhood of

Birmingham through Mr. Thos. Bolton's excellent microscopic agency, is a form admirably adapted for the observation of this same fundamental type of structure, the carapace valves in this instance being moreover composed of elegantly reticulated polygonal facets that amply repay microscopic investigation.

4.—*Zoothamnium alternans*, C. and L., (Plate IV., Fig. 5.)—This very beautiful type, identical with the *Zoothammium plumosum* of Dr. Strethill Wright, the *Z. spirale* of P. H. Gosse, ("Tenby," Plate IV., Fig. b,) and, possibly, the *Zoothamnium niveum* of C. G. Ehrenberg, (in which case this last-named specific title must take precedence of the others,) was obtained in considerable abundance attached to *Sertulariæ* and other Hydroid Zoophytes brought up with the dredge, from various depths. Some of these colonies were remarkable for their size and luxuriance of growth, those obtained from deeper water, fifty fathoms, being most notable in this respect. Compared with the more familiar fresh-water species, *Zoothamnium arbuscula*, (sometimes found in sea-water,) *Z. alternans* may be immediately distinguished by the mode in which the secondary branches are disposed with relation to the main or axial stem of the compound colony. In the present instance, these secondary branches are given off alternately, sometimes from opposite sides, and sometimes in a spiral manner, producing, in this latter instance, an exceedingly elegant, tall, plumose colonial stock, or "Zoodendrium," which may be indefinitely prolonged. Not unfrequently, and more especially in examples obtained near the shore line, the height of the entire colony does not much exceed the breadth, and, the branches originating at regular intervals on opposite sides of the main stem, the zoodendrium, as a whole, presents a flabelliform or espalier-like contour. In *Zoothamnium arbuscula*, on the other hand, all the secondary branches diverge radially or close to one another from the apex or distal termination of the main, or axial stem, which latter, being once produced, does not increase in length.

5.—*Zoothamnium dichotomum*, St. W., (Plate IV., Fig. 6.)—One or two colonies of a type that, so far as it is possible to predicate, appears to be identical with the form very briefly described in "Pritchard's Infusoria" under the above title, were obtained from the lower depth of fifty fathoms. The zoodendrium, in this instance, is built up by the more or less regular dichotomous division of a somewhat slender primary, or axial stem, the ultimate divisions, or pedicles, which support the associated zooids being of considerable length. In no other species of *Zoothamnium*, as yet described, does the supporting stem exhibit such a well-marked dichotomous plan of growth. The *Z. Cienkowskii*, of Wrzesniowski, and *Z. elegans* of De Udekim, present the nearest approach to the same, but in both of these there exists a considerable distinction in the proportionate length and thickness of the axial stem and supporting pedicles. In every instance, two or three larger reproductive zooids (Plate IV., Fig. 6*a*) were found attached towards the bases of the main branches, which were conspicuously distinct from the ordinary or alimentary zooids by their ovate instead of campanulate contour, and the coarse transverse striation of their cuticula. Dr. Strethill Wright's original comparison of the contour of the zooids of this species to that of the fruit of the Wild Rose (*Rosa canina*) would appear to apply only to these more conspicuous reproductive units.

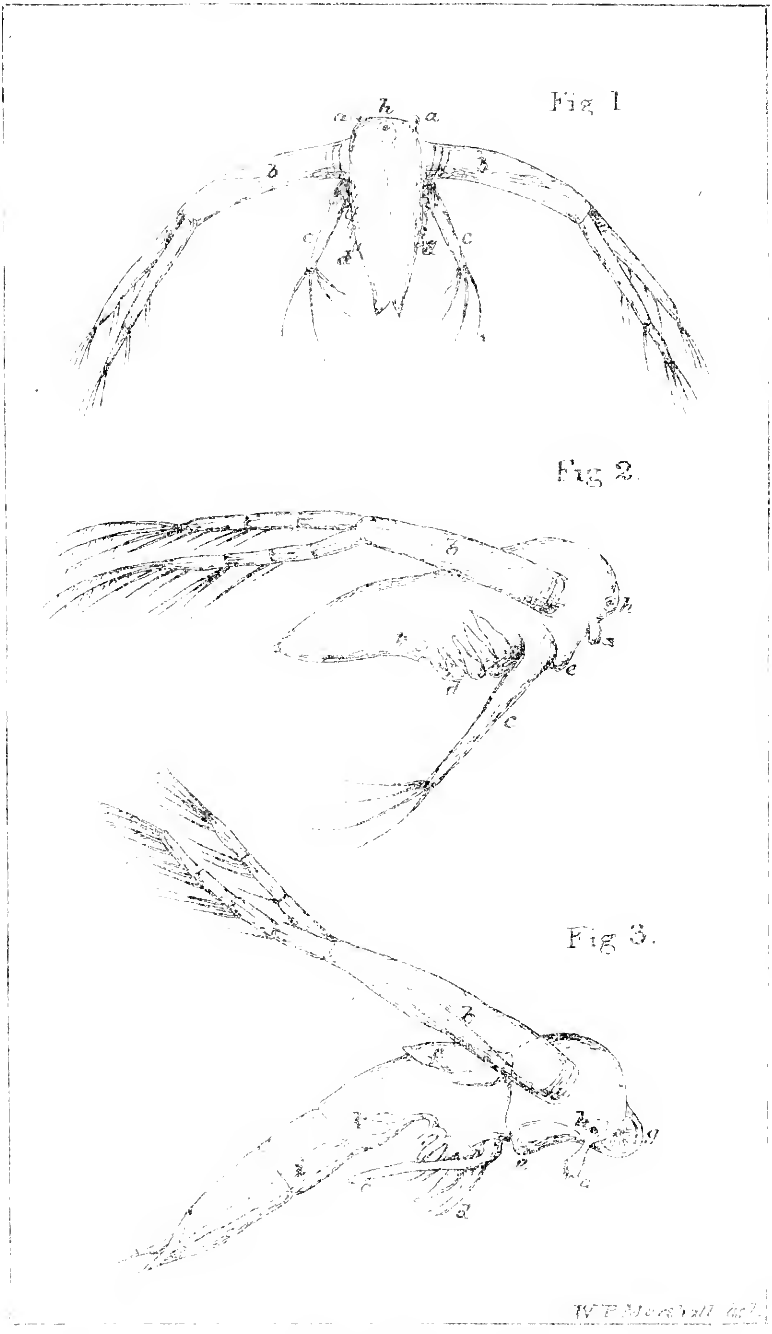
6.—*Follicularia ampulla*, Mull. sp., (Plate IV., Figs. 7 to 9.)—Among the shell *débris* brought up from a depth of fifty fathoms, the valve of a *Pecten* was encountered, whose inner surface was thickly sprinkled with what appeared to the unassisted vision as mere dark-greenish specks. Examined with the microscope, it was found that each of these latter represented an animalcule of bottle-green colour, contained in a decumbent flask-shaped lorica, permeated with a fainter shade of the same tint, and corresponding with the type originally described by O. F. Muller in the year 1786, under the title of *Vorticella ampulla*. Although recognised by Lamarck in the year 1816 as the type of a new genus, upon which he conferred the title of *Follicularia*, it is only within a comparatively recent date that this same animalcule has been almost simultaneously rediscovered and renamed; Dr. Strethill Wright, on the one hand, and M.M. Claperède and Lachmann on the other, encountering and conferring upon it the respective titles of *Lagotia* and *Freia*. The Genevan Naturalists possess, by an interval of two years, the prior claim, and their title of *Freia* is most generally adopted. There can be no doubt, however, that both these two must give place to the still older one that originated with Lamarck. To the titles of *Freia* and *Lagotia* alike several presumed distinct and well substantiated specific varieties have been relegated. Instances referable to the first-named category are afforded by the several types described by Dr. Strethill Wright under the respective names of *Lagotia viridis*, *L. hyalina*, *L. atropurpurea*, and *L. producta*, all of which, however, are shown by Stein in his Monograph of the Heterotricha to pass, by almost imperceptible gradations, into one another. Stein's decision in this connection has been amply borne out by an examination of the Falmouth examples, among which, on the same Pecten shell, both the simpler ovate and comparatively neckless, and the long annulated necked types were encountered, with every intermediate variation. Morphologically the animalcule of Follicularia may be compared to a Stentor, having its characteristic trumpet-shaped oral region produced into two lateral ear-like lobes, round which, as in the sub-circular disc of Stentor, the strong rhythmically vibratile adoral cilia are produced, and bring food material to the oral aperture, situated at the base of these two lobes. Although the representatives of the genus Follicularia are almost exclusively marine, I have for some time been familiar with a fresh-water type, discovered in the neighbourhood of Stourbridge, by Mr. Thomas Bolton, upon which I have conferred the title of *Follicularia (Freia) Boltonii*.

7.—*Hemiophrya (Podophrya) gemmipara*, Hertwig, (Plate IV., Figs. 10 and 11.)—This and the type next referred to belongs to that remarkable group of the infusoria known by the title of the Suctoria or Tentaculifera, typified by the genus *Acineta*, and distinguished by the possession of tubular tentacle-like appendages, each of which usually terminates in a sucker-like and slightly expanded disc. With these suctorial organs other animalcules are seized, and their protoplasmic contents sucked out and transferred to their own bodies. Many of these Acinetidæ during a considerable part of their existence lead an endoparasitic life within the body substance of larger Ciliate Infusoria, such as Vorticella and Paramecium, a circumstance which led Stein to infer that the Acinetidæ were not independent organisms, but developmental phases of their selected hosts. This hypothesis, however, is now entirely abandoned, and *Acineta* and its allies recognised as representing an entirely independent, extensive, and highly interesting Protozoic group. *Hemiophrya gemmipara* was first described by Dr. Hertwig in the year 1875, "Morphologisches Jahrbuch," Band I.,) as a species of *Podophrya*, and has been adopted as the type of an independent genus by myself, ("Manual of the Infusoria," now going to press,) with reference to the peculiar character of the tentacular appendages first pointed out by its discoverer, and frequently confirmed by my own personal observation. These appendages are, in fact, of two sorts, consisting partly of the ordinary tubular and suctorial organs, and partly of non-tubular ones, which are simply prehensile, thus resembling pseudopodia, and which, extending peripherally to a considerable distance, seize and bring food material within reach of the suckers. The specific name of *gemmipara* has been conferred by Hertwig on this type with relation to its conspicuous gemmiparous mode of reproduction. Large bud-like processes, varying from one or two to as many as six or eight in number, are developed at the distal extremity of the body; within each of these a diverticulum of the branching endoplast or nucleus is produced, and the entire bud or buds are ultimately constricted off and set free in the form of free-swimming ciliated embryos. Examples of this interesting type were encountered in the polypidoms of *Bugula*, *Crisia*, and other Polyzoa obtained from various depths, and with the aid of osmic acid specimens were successfully mounted exhibiting the tentacles in a condition of full expansion, as also with the characteristic embryos attached.

8.—*Ophryodendron pedicellatum*, Hincks, (Plate IV., Figs. 12 to 14.)—This singular form, figured and described at length by the Rev. Thomas Hincks in the "Quarterly Journal of Microscopical Science" for January, 1873, and obtained by him at Ilfracombe, North Devon, was sparingly encountered, and on one occasion only, attached to a species of *Plumularia*, brought up with the deeper dredgings. In their normal condition the animalcules of this species are separable into zooids of two denominations. Both are seated on short pedicles, and possess, in the one instance, a simple vermiform contour, with a more attenuated distal termination, and in the other have a cup-shaped basal region or body-mass, from the centre of which is produced an attenuate highly extensile and retractile proboscidiform organ, the apex of the same supporting a fascicle of minute tentacle-like processes, which, when the proboscis is exerted, are maintained in a state of active motion. Among the examples obtained at Falmouth, proboscidiform zooids were alone encountered, and the illustration of the vermiform zooid here given is reproduced from Mr. Hincks's figures. In two other species of this remarkable genus, obtained and examined by myself in the Channel Islands, *O. sertulariæ*, St. W., and *O. multicapitatum*, S. K., both proboscidiform and vermiform zooids occurred in abundance, and are temporarily united in the same animalcule. The last-named type, *Ophryodendron multicapitatum*, n. sp., is especially noteworthy, inasmuch as a single zooid may possess as many as three or even four proboscidiform appendages.* Although the various species of *Ophryodendron* are usually assigned to the section of the Tentaculifera, the singular proboscis-like organs being presumed to represent a modification of the tentacula of the ordinary Acinetæ, the true significance and morphological position of these very remarkable beings has yet to be elucidated. So far as speculation is assisted by the facts of embryological development, the evidence is certainly in favour of their Acinete affinities, the internally produced embryos in the case of *Ophryodendron abietinum* being shown by Claperde and Lachmann to accord essentially with those of many normal representatives of the genera *Acineta* and *Podophrya*, and to exhibit in common with the same an Hypotrichous plan of ciliation.

* A delineation of this remarkable species is added for the purpose of comparison. See Plate IV., Figs. 15 and 16.

Plate III.



Leptodora hyalina

ON THE HABITS AND LIFE-HISTORY OF LEPTODORA HYALINA.

BY A. MILNES MARSHALL, D.SC., ETC.,
PROFESSOR OF ZOOLOGY IN THE OWENS COLLEGE.

Read before the Society March 2, 1880.

In view of the approach of another season for obtaining specimens of this new and specially interesting Entomostracon, and for investigating its life-history, the following notes of the Continental experience and study of this creature may be found of service. They are extracted from the German memoir by Weismann, "On the Structure and Life-history of Leptodora Hyalina," which appeared first in the Zeitschrift für wissenschaftliche Zoologie for 1874, and was subsequently republished in a separate form. This memoir, a carefully written and detailed treatise of 70 pages, illustrated by six large plates, is by far the most complete and accurate account of Leptodora that has yet appeared.

References to Plate III.

The Figures, which are copied from Bronn's Klassen und Ordnungen des Thierreichs, represent three stages in the development of the spring brood of Leptodora.

a. Anterior pair of antennæ, or antennules.
b. Posterior pair of antennæ, or antennæ proper.
c. Mandibles.
d. Thoracic appendages.
e. Labrum, or upper lip.
f. Carapace.
g. Compound eye of adult.
h. Larval or Nauplius eye.
i. Intestine.
k. Ovary.

Fig. 1.—First stage in the development of the spring brood, seen from the dorsal surface. This earliest or Nauplius stage possesses only three pairs of jointed appendages—antennules *a*, antennæ *b*, and mandibles *c*. The great size of the second pair, the antennæ, *b*, is obviously correlated with their large size in the adult, and is a point serving to distinguish the Nauplius larva of Leptodora from the Nauplii of other Crustacea.

Fig. 2.—A somewhat older larva seen from the right side. In addition to the marked increase in size, the most important changes are the greater development of the thoracic appendages, *d*. the appearance of the ovary, *k*, (all the spring brood are said to develope into females,) and the rudiment of the compound adult eye, *g*.

Fig. 3.—A still older larva, seen from the right side. The thoracic appendages, *d*, have now grown very considerably; the carapace, *f*, has begun to appear; the limb-like portion or palp of the mandibles, *c*, has undergone not only a relative but an actual decrease in size; the compound eye, *g*, has greatly increased in size; the abdomen is segmented; and the alimentary canal has acquired the arrangement characteristic of the adult.

In Figs. 2 and 3 the appendages of one side only of the body are shown.

Note.—In the original figures, which are very roughly drawn, the larval or Nauplius eye is not distinctly shown. As its presence is of extreme importance as distinguishing the spring brood from all other generations, and as my sole object in giving these figures is to facilitate the recognition of the larva, I have inserted this eye in the figures in the position which it holds according to Weismann's descriptions. I hope that before long some of the Birmingham Naturalists may be able to give us more satisfactory figures of these developmental stages.

A. M. M.

Weismann first met with Leptodora in Lake Constance during the summer of 1873, and supposing it to be new to science devoted much time and trouble to working out its life-history during this and the following year. The principal results to which he was led, as contained in the paper above referred to, are as follows.

For the capture of Leptodora Weismann employed a fine net dragged immediately beneath the surface of the water; he notes that wherever they occur they are found in large numbers, They appear to avoid strong light; thus, in clear sunshine none are found at the surface, though they may abound at a depth of a few feet; at night they occur quite at the surface, but bright moonlight is sufficient to drive them down again. The best time for capturing them is in gloomy weather, towards evening, or on dark nights. Weismann suggests, however, that this shunning of the light may be only apparent after all, and due to the fact that Cyclops, which, according to him, is the chief food of Leptodora, has the same habit, so that Leptodora may be merely following its prey about, instead of being itself directly influenced by light. Still the fact is one of some interest, and one a knowledge of which may greatly facilitate the capture of this interesting Entomostracon.

Swimming is effected entirely by means of the posterior antennæ, and is comparatively slow. It is only in extremest necessity, when stuck fast, that the abdomen is used for progression, while the feet appear to be never used for this purpose.

Cladocera may be divided into a littoral group and a deep-water group, to the latter of which Leptodora belongs. It is only found in water clear from vegetation, and away from the shore. When kept in captivity, algæ and particles of dirt soon attach themselves to the swimming arms or antennæ, and the animals rarely survive so long as a fortnight. They are not uncommonly attacked by a fungus, which grows inwards through the integument and gradually kills them.

Weismann describes Leptodora as habitually lying quietly stretched out in the water, like Corethra, and waiting till its prey comes within reach of its foot-jaws; he considers that the terminal dilatation of the alimentary canal partially counterbalances the thorax and head, and so aids in the maintenance of the horizontal position.

The relations of Leptodora to the other Cladocera are discussed by Weismann at considerable length. He points out how the long segmented abdomen of Leptodora is correlated with the rudimentary condition of its carapace, and shows how in such forms as Bythotrephes and Polyphemus we have a gradual increase in the size of the carapace, accompanied by a gradual diminution in the length of the abdomen and fusion of its different segments; while finally in Daphnia the carapace has grown backwards and downwards, so as to completely enclose the whole animal —a change accompanied by complete fusion of thorax and abdomen, in which no indication of the constituent segments is visible in the adult. The reduction of the body and fusion of the segments is carried to a stil higher point in the Ostracoda, such as Cypris, in which also the bivalve shell reaches its highest development.

The absence of branchial lamellæ on the legs in Leptodora is also to be correlated with the rudimentary condition of the carapace; these lamellæ, which attain their greatest development in Lynceidæ and Daphniadæ, in which also the carapace is most fully developed, probably serve to maintain a current of water through the shell, rather than to act themselves as direct respiratory organs, and they are therefore needless when the shell is absent or rudimentary.

From these arguments Weismann concludes that Leptodora is the *most primitive form* of Cladocera with which we are acquainted—a conclusion supported in a remarkable manner by what little is known of its development.

Leptodora, like Cladocera in general, appears to form two kinds of ova, which may be distinguished as winter ova and summer ova. The two kinds of ova differ markedly in appearance and in their subsequent mode of development, though both kinds may occur at one time in the ovary of a single female. The difference between the two appears to depend mainly on the winter ova being fertilised while the summer ova develope parthenogenetically. This, however, is not definitely proved; all that is known is that males occur very rarely or not at all until late in the autumn, and that their occurrence is apparently coincident with the development by the females of winter ova. From the summer ova are developed young which undergo no marked metamorphosis, and resemble their parents at the time of leaving the egg. The winter ova, on the other hand, produce embryos which when hatched have the form known as "Nauplius," and only attain the form of their parents after a long and gradual series of metamorphoses, accompanying the successive moultings of their skin.

The occurrence of this Nauplius larva is of very great interest. A Nauplius is characterised by possessing only three pairs of appendages (corresponding to the two pairs of antennæ and the pair of mandibles of the adult), a rudimentary unsegmented abdomen, and a single median eye instead of the double eye of the adult. Nauplius larvæ are very general among the Entomostraca, but till the life-history of Leptodora was worked out by Sars in 1873 the Cladocera were supposed to stand alone among Entomostraca in never passing through the Nauplius stage. Leptodora serves in this respect to connect the Cladocera with the other Entomostraca, and in this way fully proves its title to rank as one of the most primitive forms of Cladocera known.

The Nauplius larvæ of different Crustacea generally have some resemblances to the adult forms, and this is particularly well shown by the Nauplius of Leptodora, in which, while the anterior antennæ are very small, the posterior antennæ are very large indeed, thus foreshadowing their enormous size in the adult. As these early stages are of very great interest and importance, figures of some of the most important larval stages of Leptodora accompany this paper, in the hope that they may facilitate the recognition of the forms when actually met with.

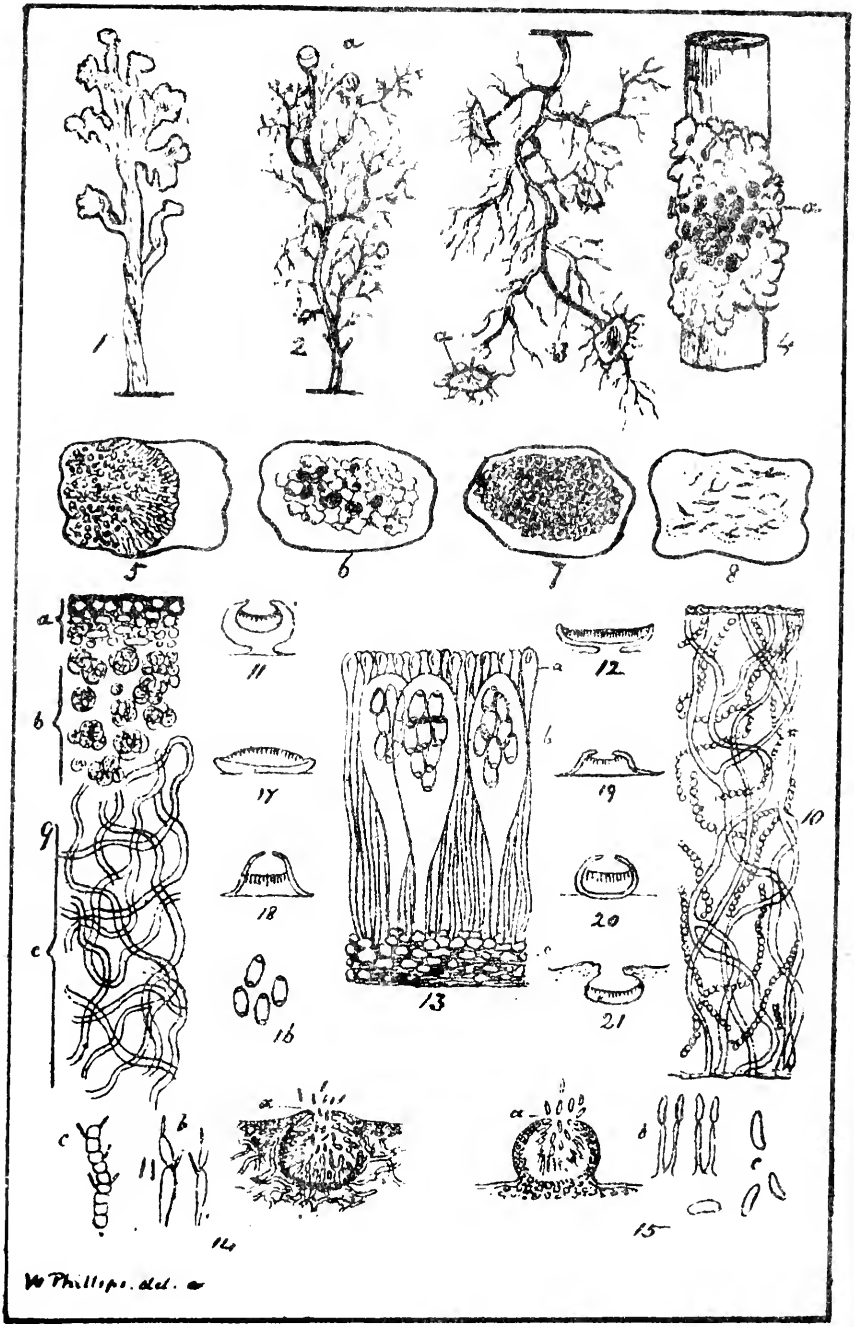
The winter ova, it appears, give rise in March or April to larvæ which hatch in the form of Nauplii; these moult several times, and gradually acquire the form of the adult. This *spring brood* may be always recognised by the fact that they retain even when adult the median eye of the Nauplius, *in addition* to the large double compound eye of the adult; the larval eye persisting as a small black spot on the under surface of the brain. The spring brood gives rise to females only; these females produce summer ova which develope into adults, and produce other summer ova, and so on; males do not appear until the autumn, and even then are much scarcer than the females.

At the end of his paper Weismann gives a list of all the localities in which Leptodora had been observed up to the date of his paper, 1874. The first specimens were found by Focke in 1844 in the town moat of Bremen, which is described as being clear water more than 100 feet wide, and moderately deep. Lilljeborg found it in Sweden in 1860. The males were first discovered by Müller in 1867 in Danish lakes, and in Lakes Geneva and Constance. In 1868 Wagner found it in a Russian lake near Kasan, and, ignorant of its previous discovery, re-named it *Hyalosoma dux*. It has also occurred in Lake Maggiore, in Italy, but according to Weismann is not found in Lake Zurich, nor in the small lakes near Lake Constance.

The above paper suggests several points well worthy the attention of our local naturalists during the present and ensuing months. The occurrence of the Nauplius form is of extreme interest, as an isolated instance among Cladocera; while the retention by the spring brood of the Nauplius eye affords a ready means of recognising them in their later stages. It will be very important to ascertain whether any of this spring brood develope into males, *i.e.*, whether any males are met with possessing the Nauplius eye. Any direct confirmation of the parthenoge etic nature of the summer ova would be also very valuable.

A point which I would ask any one to determine who has the opportunity of observing a living Leptodora, is the nature of the process of *respiration*. This will probably be found to be effected, as in Cyclops and other Entomostraca, by means of rhythmical contractions of the terminal dilated portion of the alimentary canal; water being alternately sucked into and ejected from this dilated portion. The arrangement of the muscular system strongly suggests that this is the real mode of respiration, a point which would probably be settled by a few minutes' observation of a healthy specimen.

Plate V.



British Lichens

BRITISH LICHENS: HINTS HOW TO STUDY THEM.

BY W. PHILLIPS, F.L.S.

Read before the Society, March 9th and 30th, 1880.

The group of plants classed as Lichens, though for the most part minute in stature, offer a highly interesting field of study to the lover of nature, and will well repay the labour bestowed upon them by presenting before the mind much beauty of form and curiosity of structure. To him who wants an inducement to seek the country lane, the wooded park, or the breezy hill side, no better one can be found than in the pursuit of these attractive little plants, which need no care in drying, and little space for storing. The thousands of species that lie scattered on the surface of old trees, the face of weathered rocks, and on heathy pastures, will supply an exhaustless source of pleasure to the man who is capable of appreciating the wisdom of the great Creator, displayed in the lower forms of vegetable life; nor is there that difficulty in their study which some people have imagined. As in other departments of botany, as indeed in every branch of human knowledge, there are certain initial difficulties—those which stand on the threshold of the subject—which give some trouble, but when these are surmounted the course becomes easy and

REFERENCES TO PLATE V.

Fig. 1.—*Cetraria Islandica*, a single frond, natural size.
Fig. 2.—*Sphærophoron coralloides*, natural size, *a*, *apothecium*.
Fig. 3.—*Usnea barbata*, natural size; *a*, *apothecium*.
Fig. 4.—*Physcia parietina*, natural size on wood; *a*, *apothecia*.
Fig. 5.—*Placodium callopismum*, a portion of a specimen, natural size.
Fig. 6.—*Squamaria crassa*, natural size.
Fig. 7.—*Lecidea geographica*, natural size.
Fig. 8.—*Graphis elegans*, natural size.
Fig. 9.—Perpendicular section of the thallus of *Physcia parietina*, much magnified; showing the three strata, *a* cortical layer, *b* gonidial layer, *c* medullary layer.
Fig 10.—Perpendicular section of the thallus of a *Leptogium*, much magnified; showing the intermixed hyphæ and gonidial necklaces.
Figs. 11 & 12.—Perpendicular sections of apothecia of *Physcia parietina*, very little magnified; the first a young, the second an older individual.
Fig. 13.—A perpendicular section of the same, more highly magnified; *a* asci with sporidia, *b* paraphyses, *c* hypothecium.
Fig. 14.—Perpendicular section of a spermagonium immersed in the thallus, highly magnified; *a* ostiolum, *b* and *c* different forms of sterigmata, showing the spermatia *in situ*.
Fig. 15.—Perpendicular section of a pycnidium seated on the thallus, highly magnified; *a* ostiolum, *b* basidia and spores, *c* detached spores more highly magnified.
Fig. 16.—Spores of *Physcia parietina*, highly magnified.
Fig. 17.—Perpendicular section of a lecideine apothecium, slightly magnified.
Fig. 18.—Perpendicular section of a dimidiate peridium of a *Verrucaria*, slightly magnified.
Fig. 19.—Perpendicular section of a peridium of a *Graphis*, showing the dimidiate form, slightly magnified.
Fig. 20.—Perpendicular section of an entire peridium of an *Opegrapha*, slightly magnified.
Fig. 21.—A perpendicular section of an apothecium immersed in the thallus, slightly magnified.

pleasant. It is with the view of helping the student over these initial difficulties that the present paper has been written.

The vegetable kingdom is divided into two great sections, the *Phanerogamia* and the *Cryptogamia*, the former possessing flowers containing male and female organs, the latter being destitute of flowers, and having their male and female organs less conspicuous or altogether concealed within special receptacles. Lichens* belong to the section *Cryptogamia*. They are closely related to other sub-divisions in this section, viz., *Fungi* and *Algæ*, the line of separation on either side being so indistinct that it is not always easy to say where it runs. Nature, indeed, has drawn no definite line even between the animal and vegetable kingdoms, much less between the sub-divisions of the vegetable kingdom. Notwithstanding this near approach of Lichens to Algæ on the one hand, and Fungi on the other, the students of each have, by mutual consent, agreed to certain limitations which serve all practical purposes. Lichens are distinguished from certain Fungi to which they have a resemblance by possessing in their structure the green bodies called *gonidia*, of which we shall have to speak at length hereafter; from Algæ they are distinguished by bearing reproductive spores in asci. Other points of difference can only be understood by the student as he becomes more fully acquainted with the subject, hence these must suffice for the present.

A perfect Lichen consists of the *vegetative* part called the *Thallus*;† and the fruit-bearing receptacles, the *Apothecia*,‡ considered to be the female organs, seated on the thallus; with which are found associated the *Spermagonia*§ and the *Pycnides*,‖ considered to be the male organs. Although every Lichen should, theoretically, have these parts all present, it must be understood that the thallus is often so imperfectly developed that it is scarcely discernible, or, as in parasitic species, is absent, while in others, though the thallus is perfectly developed, the apothecia are hardly ever to be seen, and the spermagonia and pycnidia are still more rarely to be found.

We will proceed to notice these various parts more in detail, beginning with

THE THALLUS.

I.—The thallus differs much, according to the species, in form, size, colour, and texture. Having regard to the surface on which a Lichen grows, the thallus may be *upright* or *prostrate*, *i.e.*, vertical or horizontal.

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* This word, which is pronounced Likens, the ch being hard, is said to be derived from the Greek word λειχην a wart.

† From θαλλός a frond or green leaf.

‡ From ἀπο upon, and θήκη a sack.

§ From σπέρμα a seed, and γονὴ generation, in allusion to their function.

‖ From πυκνότης, indicating many things pressed one against the other, probably on account of their close growth.

The *upright* thallus may assume one of two forms known as the *fruticulose** and *filamentous* forms.

1st.—The *fruticulose* form is so named because of its general resemblance to a miniature shrub. It is attached at the base, from which it ascends in one or more stems, with or without branches, which are flat or cylindrical. The most familiar illustration of this form is that of the Iceland moss of commerce (*Cetraria Islandica,*) (Plate V., Fig. 1,) imported and sold in every chemist's shop.

2nd.—The *filamentous* form is that in which the stems arise from a small base of attachment, and consist of thread-like, rigid, or flaccid, upright, prostrate, or pendulous filaments, often repeatedly branched. The Beard Moss (*Usnea barbata*) (Plate V., Fig. 3.) so frequently to be seen on old trees, is an example of this form.

The *prostrate* thallus may be either attached to its support by a small space only, or by the whole of its under surface. As this division includes the major part of Lichens it has been sub-divided into, 1st, the foliaceous, and 2nd, the crustaceous forms.

1st.—The *foliaceous* thallus.—This consists of leaf-like expansions, spreading horizontally, attached by one or more points on the under surface to the substance on which it grows. It is often cut or torn at the margin into more or less irregular lobes, which at times overlap each other. In some species having a foliaceous thallus the attachment beneath is by numerous small filaments, which, though suggesting the idea of rootlets, serve no such purpose; they are called *rhizinæ*.† *Parmelia saxatilis*, one of the commonest British species on rocks and trees, presents these rhizinæ in abundance.

2nd.—The *crustaceous* thallus.—As the name implies, this forms a more or less thick crust, generally attached by the whole of its under side, but often free at the margin. Some of the chief forms of this must be particularised. It begins to depart from those already mentioned by the

Squamulose‡ thallus.—This is formed of small scales, either detached or united to each other by the margin, and affixed to the substance on which it grows by its under surface. The outline is very variable, affording important characters in the distinction of species. *Squamaria crassa*, a common species on the earth in limestone districts, will illustrate this form of thallus. (Plate V., Fig. 6.)

Granulose thallus.—This is formed by a thin layer of irregularly sized granules, each granule separated from the other, or united into a continuous surface. It prevails largely in the genus *Lecidea*.

* From *frutex*, Latin for shrub, *fruticulose*—diminutive.

† From ῥίζα a root.

‡ From *squama*, Latin for the scale of a fish.

Scurfy thallus.—In this form the surface is torn up into minute flat scales, thickly distributed, giving it the scurfy aspect implied by the name as ordinarily understood.

*Areolate** thallus.—In this form the crust of the thallus is divided into minute spaces, which are either depressed, flat, or convex. These spaces are sometimes rendered more conspicuous by having a border round each, formed by a fissure in the crust. This occurs abundantly in the genus *Lecidea*. (Plate V., Fig. 7.)

Pulverulent† thallus.—This is the granulose thallus, having the granules more minutely divided, appearing under a pocket lens as if dusted over the surface with a fine dry powder. This is one of the least developed forms of a Lichen thallus.

Besides these more marked forms of the thallus there are many variations, the terms for describing which will be found in an admirable glossary in "Leighton's Lichen Flora."

There are two terms of frequent use in describing the thallus which it may be well to explain here. When a thallus presents a definite outline, clearly marking how far it extends on the rock or bark, it is said to be *determinate*. When there is no distinct or clearly defined outline, but it dies away in patches, it is said to be *effused* or *indeterminate*.

The *size* of the thallus varies from a minute point only to be seen by the aid of a magnifying glass up to one or even two square feet in superficial extent. We refer exclusively to British Lichens. The genera which contain the largest species are *Sticta*, *Stictina*, *Peltigera*, *Parmelia*, *Usnea*, and *Ramalina*. Occasionally species belonging to other genera than these named, will, under particularly favourable circumstances, extend their thallus to an unusual size.

The *colour* of the thallus includes all shades of green, varying to yellow in one direction, to brown in another, and to blue in another. It may be black, or gray, or white ; it may be pale yellow, citron yellow, or orange yellow ; never blue or red, except modified very much by other tints. As a rule, the *gonidia* contribute largely to the colour of the thallus, and become more conspicuous when moistened by water, hence the predominance of green.

The texture of the thallus may be soft and gelatinous, as in *Collema* ; spongy, as in *Peltigera* ; fragile, as in *Stereocaulon* ; tough, as in *Cetraria* ; firm and hard as in *Roccella* ; tartarious and brittle, as in many of the *Lecideæ*. In fact, the variations are infinite.

Having thus briefly glanced at the external characters of the Lichen thallus that are mostly perceptible to the unaided vision, we shall next proceed to point out the main features of the microscopic structure of the thallus.

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* From *areola*, Latin for a little bed, or quarter, in a garden.

† From *pulvis*, Latin for dust.

If a thin, perpendicular section be taken of one of the foliaceous species, say for example *Physcia parietina*, and placed under the microscope with a little water, there will be presented to the eye of the student three distinct layers. (Plate V., Fig. 9.)

1st.—The *cortical** *layer*, which forms the upper surface or bark of the thallus. It is composed of minute cells, closely compacted together, constituting a firm membranaceous tissue. (Plate V., Fig. 9*a*.) The cells vary in size and outline, the latter being modified by their mutual pressure. The cell walls are comparatively thick, and by transmitted light show a faint degree of colour, more conspicuous in very old specimens of the Lichen. Beneath this cortical layer will be seen—

2nd.—The *gonidial*† layer, which consists of cells filled with chlorophyll, spherical, or nearly spherical, varying in size, and easily separated from each other by the slightest pressure. There would appear to be no actual union between these bodies, though produced one from the other, but they lie loosely together in a tolerably well defined stratum. (Plate V., Fig. 9*b*.) They occur in the thallus of all Lichens, though they differ considerably in form, being first, cells enclosing green granular protoplasm, as in those we have now under the microscope; second, cells containing several granules, devoid of any cell membrane, called *granula gonima*: and, third, cells arranged in chains or necklaces. (Plate V., Fig. 10.) These gonidia often thrust themselves up through the surface of the cortical layer, in clusters or heaps, producing the conditions of the thallus known as a *sorediate*‡ thallus. Some very fanciful notions have in late years been broached with regard to the relationship the gonidia bear to the thallus, to which we cannot, in the limited space at our disposal, give more than a passing notice; at the same time it must be admitted that they have the power of carrying on an existence independent of the other constituents of the thallus, and will, on a favourable surface, multiply themselves till they form a pseudo-thallus, but do not produce apothecia. Beneath the gonidial layer may be seen

3rd.—The *medullary*§ layer composed of colourless interwoven filaments, branched and tubular, being divided within at certain intervals by walls or septa. (Plate V., Fig. 9*c*.) A section of the thallus of *Peltigera canina* will show both this and the preceding layers in a clearer manner than *Parmelia saxatilis*. Beneath the medullary layer there are often present in foliaceous species the *rhizinæ* which have already been referred to, serving the purpose of attaching the Lichen firmly to its place of growth; in *Parmelia saxatilis* they are black, short, and rigid, but in *Peltigera canina* they are long, pale, and flaccid.

If we had selected a crustaceous Lichen for examination, as for example *Lecidea geographica*, (Plate V., Fig. 7.) we should have found the

* From *cortex*, Latin for rind or bark.

† From γόνη, generation, and εἶδος, resemblance, indicating their resemblance in function to the spores.

‡ The term *soredia* is from the Greek word σωρὸς, a heap, a pile, indicating the little heaps of gonidia.

§ From *medulla*, Latin for pith or marrow.

cortical, gonidial, and medullary layers in precisely the same order as above but instead of *rhizinæ* we should have seen a very thin layer of dead cellular black matter adhering closely to the surface of the stone, which is called the *hypothallus*.* This is formed by the threads first thrown out by the germinating spores, and is the earliest stage of a Lichen thallus. On quartz rock this hypothallus of *Lecidea geographica* is often to be seen in black radiating lines, while as yet no other part of the thallus has been formed.

In some of the gelatinous Lichens, as for example in *Collema*, the cortical layer is absent, while in an allied genus, *Leptogium*, it is reduced to the thinnest possible layer; the gonidial layer and the medullary are also mixed up together in one common stratum. (Plate V., Fig. 10.)

While a well developed Lichen thallus will have the characters above described, it must not be forgotten that in many species it is reduced to such insignificance that it consists of little more than a few filaments, accompanied by a few gonidia lying beneath the epidermis of the bark of a tree, or running through the disintegrated surface of a rock. In species with such an imperfectly developed thallus specimens will occur in which it cannot be detected, it is then said to be *evanescent ;* but if present and concealed beneath the epidermis of the bark it is said to be *hypophlœodal*.† This is the condition in many genera, amongst which may be mentioned *Opegrapha*, *Graphis*, *Arthonia*, and *Verrucaria*.

The Reproductive Organs of Lichens.

Having briefly described the leading characters of the Lichen thallus, our next object is to convey in as few words as possible an idea of the mode of reproduction in Lichens. This is accomplished by the means of spores, which are capable of germinating and throwing out from one or more parts of their surface fine transparent threads called *hyphæ*, which form a thin layer by becoming interlaced together, this layer as already described being the *hypothallus*. The spores are produced in a special receptacle seated on some portion of the thallus, or buried in its substance, called the

Apothecium.‡ The apothecium is capable of assuming a great number of various forms, which it is necessary should be clearly understood; but there are certain essential parts which belong alike to all forms. We will select as a specimen for illustration the common wall Physcia (*Physcia parietina*,) as it is a species usually exhibiting an abundance of apothecia. If a well-grown specimen of this Lichen be obtained by the student§ he will observe scattered about the centre of the thallus a number of orange-

* From ὑπὸ under, and θαλλὸς a frond, *i.e.*, that which underlies the thallus.

† From ὑπὸ under, and φλοιὸς the bark of a tree.

‡ From ἀπὸ, upon, and θήκη, a sac, the part bearing the asci.

§ To meet the case of such as have no means of obtaining specimens of the commoner species of the British Lichens, the author of this paper has determined to prepare small collections, correctly named, to be obtained post free on application to his address, Canonbury, Shrewsbury, at the following rates:—Elementary Collections of British Lichens, Series I., containing twenty-five specimens, 5s. 6d.; Series II., containing fifty specimens, 10s.; Series III., containing one hundred specimens, 18s.

coloured circular shields or cups, surrounded by a pale margin, seated close on the surface, or slightly raised by a broadish stem-like base; these are the apothecia (Fig. 4.) He will observe that the area enclosed by the pale margin is slightly depressed, (Fig. 12,) but less so in the older individuals; this area is called the *hymenium** by some, and the *thalamium*† by others, and is composed of a vast number of club-shaped cells, arranged in an upright position, side by side, within which are produced the spores already mentioned. These club-shaped cells are the *asci*‡ or *thecæ*,§ and each one contains in the species under examination eight spores, which escape on the rupturing of the asci at maturity These asci are not always sack-shape, being sometimes narrowly cylindrical, at others nearly spherical, with numerous intermediate variations.

The spores vary in number in each ascus, according to species, from a single one to a great number, but the most common number is eight. They also vary very much in size, form, mode of internal division, and colour. It is by the aid of these characters that species can be satisfactorily determined, as each particular species exhibits its own characteristic spore with wonderful constancy. The spores are believed to be the female organs of the plant, and to acquire their germinating power from a process of impregnation by bodies we shall proceed presently to describe; but in what stage of their existence this process takes place has not yet been satisfactorily shown.

Returning to the hymenium, the student will find other upright bodies intermixed with the asci, surrounding them on all sides, exceeding them slightly in length, but much slenderer, and thicker at the summits than below; these are the *Paraphyses.*‖ (Fig. 13*a*.) The precise function of these bodies has not been ascertained, but there can be no doubt they serve as a protection to those very important bodies the asci, whatever other functions they may perform. They occur in some species as very slender threads, either simple or branched, and are also often so united together as to be inseparable by pressure; they are then said to be *indistinct.*

This layer, called the hymenium or thalamium, composed of asci and paraphyses, is permeated by a substance called the hymenial gelatine, which holds the whole together in a compact mass. In proceeding downwards in our examination of the apothecium, we come to a layer of small cells, which forms the bed from which springs the hymenium. (Fig. 13*c*.) This layer is called the hypothecium,¶ because it underlies the asci or thecæ. The colour of this forms an important character in the large genus *Lecidea*, being either colourless or dark

* From ὑμὴν, a membrane.

† From θάλαμος, a receptacle.

‡ From ἀσκὸς, a leather bottle

§ From θήκη, a sack.

‖ From παρὰ, about, and φύω, to grow.

¶ From ὑπὸ, under, and θήκη, a sack.

coloured. We have finally to point out the excipulum, or receptacle within which the previously described parts of the apothecium are contained. In the species under examination this is formed by a continuation of the substance of the thallus, which has taken the shape of a miniature cup, in the bottom of which the hymenium and the hypothecium are seated. (Figs. 11, 12.) If a perpendicular section be made through the middle of the apothecium, carrying it down through the thallus, there will be no difficulty in seeing, with a pocket lens, the arrangement of all the parts in the order we have here described them. It is only in certain genera that the excipulum is formed of the same tissue as the thallus. It is often formed of its own special tissue, in which case it is called a proper excipulum; and the margin it forms when looked at from above is called a proper margin, whereas in the former case it is called a thalline excipulum and a thalline margin.

There is yet one more term used in reference to the apothecium, which it is necessary to explain—the *epithecium*.* This term is used to denote the upper surface of the hymenium, the part that is presented to the light.

The various parts of the apothecium we have described are essentially the same in all, though assuming a multitude of different forms; hence the student must learn to recognise them however they present themselves in nature. To aid him in this we will point out some of the more striking modifications of the apothecium.

The *Peltiform*† apothecium, is so called because of its resemblance to a small shield. It may be in the form of a depression, sunk into the thallus, as in *Solorina*, presenting no margin; or it may be a convex disc arising from the upper surface of the thallus, and having a margin, as in *Peltigera*. It occurs in some genera on the under side of the thallus, as in *Nephronium*.

The *lecanorine* apothecium is so called because it is the characteristic form in the genus Lecanora, and, as we have seen in the specimen under examination, has an excipulum formed from the substance of the thallus. It may be innate or immersed in the thallus, which forms a wart-like tubercle around it, at first entirely closed, afterwards open at the summit, as in *Thelotrema* and *Urceolaria* (Fig. 19;) or it may be raised above the general surface of the thallus on a short stem-like base, as in *Physcia*, *Parmelia*, and *Lecanora*. (Figs. 11, 12.)

The *lecideine* apothecium is that in which the tissue of the excipulum is essentially different from that of the thallus, being, like the preceding forms, either sunk into the thallus or seated on its surface. (Figs. 21, 17.) In this form of apothecium the excipulum is a continuation of the hypothecium as already described, or perhaps more properly the latter is a continuation of the former, presenting no very well defined line of separation. It prevails in the large genus *Lecidea*, hence the name *lecideine*. It is sometimes also called *patelliform*.

* From ἐπὶ, upon, and θήκη, a sack.

† From *pelta*, Latin for target.

The *lirelline** apothecium is that which forms an elevated ridge, with an opening in the form of a slit running along the top. It prevails in the pictorial Lichens, those which resemble writing, as *Opegrapha* and *Graphis*. The receptacle here is usually black, and consists of a firm cellular substance, and is generally called the *perithecium*†. If the perithecium entirely surrounds the thalamium, it is called entire (Fig. 20 ;) if it be deficient beneath, it is called dimidiate. (Fig. 18.) The lirellæ are very variable in form, being immersed or slightly elevated, broad or narrow, straight or curved, simple or branched.

The *pyrenodine*‡ apothecium is that in which the excipulum consists of a closed receptacle composed of a dense leathery or brittle substance, with a minute pore at the top caled the *ostiolum*§. It may be globose or conical, superficial, *i.e.*, seated on the surface, or immersed in the thallus. As in the lirelline apothecium, if it surround the thalamium it is called entire, and if deficient beneath it is called dimidiate, and also has the name perithecium applied to it. It is the characteristic form in *Verrucaria*, approaching very closely the genus *Sphæria* in fungi.

These various devices of nature presented to us in the structure of the apothecium of Lichens are directed towards one object—the development, protection, maturing, and dispersing those important bodies, the spores. As we have before hinted, these bodies being regarded as the female organs, we must now turn our attention to the organs designed for their fertilisation. These are believed to exist in the *Spermagonia* and the *Pycnides*, which shall now be briefly described.

The *spermagonia* are minute spherical bodies found on the surface of or embedded in, the cortical layer of the thallus. If one of these be carefully dissected through the middle it will be found to have its interior lined with excessively minute thread-shaped jointed upright bodies, (Fig. 14*c*,) which are called *sterigmata*. From the summits, and also from the joints of these arise still smaller, rod-like cylindrical bodies, which are either straight or curved, these are the *spermatia*. They are produced in great numbers, and find their way through an opening in the summit of the spermagonium into the open air to perform their function of fertilising the hymenium of the apothecium.

The *pycnides* are minute dark-coloured bodies somewhat spherical in form, seated on the cortical layer of the thallus, the interior of which is lined with a layer of simple upright filaments bearing on their summits spore-like bodies, which are called *stylospores*, (Fig. 15, *a*, *b*, *c*.) The filaments bearing the stylospores are called *basidia*. The stylospores are allowed to escape by a pore in the summit of the pycnides. We have now completed the drier part of our subject, not without regretting that so many hard names have had to be used to convey our meaning, the

* From *lirella* Latin for furrow.

† From περὶ, around, and θήκη, a sack.

‡ From *pyren*, Latin for kernel, or stone of fruit.

§ From *ostiolum*, Latin for a little door.

acquirement of a knowledge of which is the tax we all have to pay on entering the domain of science. Once acquired, however, they become our greatest aids to study, and lead to a precision of thought which more familiar but ill-defined terms would utterly fail in. Leaving this thought to console the student for his trouble, we will now turn to easier branches of our subject.

As no man can work without tools, we will here specify the essential appliances required for collecting, preserving, and studying Lichens. These may be classed under two heads—1st. appliances for collecting; 2nd, those for home study.

I.—*Appliances for Collecting.*—A pocket lens, having a focal length of 2in. or 2½in., which can be obtained from any optician for a shilling. Some prefer having one with three powers, in which case a 1in., a 2in., and a 3in. will be found a convenient combination. The external characters of most species of Lichens can be made out with sufficient precision by the aid of these powers, which is all that is required in field work. The rest must be left for home study.

A hammer such as Geologists carry, with one end broad enough to use with a chisel.

A stonemason's chisel, of good temper, for detaching portions of the rock on which the Lichens grow.

A strong clasp-knife, for removing the bark of trees to which the Lichens attach themselves.

A leather satchel for carrying specimens.

An ample supply of paper for folding up specimens.

II.—*Appliances for Home Study.*—The most important of these is a good compound microscope. It does not necessarily follow that a microscope suitable for the examination of Lichens should be a very expensive instrument. English and foreign makers now supply for about £5 an instrument which will answer all the purposes of the student; but if his means admit of it, there is no economy in having a poor or imperfect microscope, and the best within reach should be procured. Two powers are essential, one a low power, magnifying fifty times, (linear,) the other magnifying from 350 to 400 times (linear.) With such an instrument all can be done that is required.

A small knife for cutting thin sections, with a supply of glass slides and covering glasses, should accompany the microscope.

A glue-pot, with a supply of glue for fastening down specimens on paper, on which to write the names of the species, and the localities where they were gathered, with any other necessary remark. Gum should never be used for this purpose, as many valuable specimens will be lost by being rubbed off in the herbarium. The only specimens that present any difficulty in making secure are such as grow on loose sand or soil, and for these the better plan is to make a pool of dissolved glue on the paper, and place on it the mass of earth while still damp, when the glue, if not too thick, will permeate the whole mass and bind it together.

The most friable specimens by this means can be kept together for any length of time, and will endure the rough usage of the herbarium.*

A good supply of stoutish cartridge-paper should be kept always at hand, cut into squares of about 4in. by 6in., or 6in. by 6in., according to the size of the specimen Lichen it is to receive, allowing room for notes and drawings of the internal characters. A further supply should be ready, about 10in. by 8in., for placing in a portfolio, on which the smaller pieces bearing the specimens can be pinned to allow for easy removal when they are required for examination. These larger sheets will carry several specimens of the same species, and should have the specific name written distinctly at the bottom of the sheet at the left-hand corner. About fifty of these will be sufficient to place in one portfolio, which may be made of strong cardboard, with tape strings to keep it closed. On the back of the portfolio may be written the genus or genera to which it is devoted, and it can be placed as a book in an ordinary book-case. The size given above is that of Mudd's published Fasciculi of British Lichens, and has the advantage of not being too large for an ordinary book-shelf. Half-a-dozen such portfolios will suffice for a beginner, but it is necessary to fix on the proper size at the commencement, that no inconvenience may be experienced hereafter by discovering that a different size would have been much more suitable.

Three bottles to contain the following chemicals for testing the reaction of Lichens:—A solution of iodine, iodide of potassium, and chloride of lime. Three glass brushes, one to be used for each of the chemicals. Further instructions how to apply these will be given in another place, but I would here remark that great care should be taken not to mix these chemicals by pouring one into a vessel which has contained another, without first washing it, or by using the same brush for two chemicals, as the result of testing would be rendered altogether worthless.

Where to collect Lichens will now require a few remarks. Supposing the student to have provided himself with the necessary appliances just enumerated, he will now undertake his first excursion in pursuit of specimens. He must get well away into the country, at a distance from towns and smoke, for the Lichen loves pure air and free ventilation. It has long since been remarked that they rarely, if ever, attain their perfect maturity in the vicinity of cities or manufactories, where much smoke is found in the atmosphere. Old forests, far-stretching moorland, airy mountain sides, with here and there the jutting rock thrusting its head through the springing heather, the cliffs of sea-shores watered by the spray of the ocean, the stony beds of dry watercourses, such are the places he will find most productive. But if such attractive scenes for Lichen-hunting cannot be visited, the student must make up for the want of such by extra diligence in less promising localities. Some of the most highly-prized species have been found on old rails in the last

* Still greater security can be given to fragile specimens by glueing them in stout pill-boxes, the wall of the pill-boxes preventing the pressure falling on the Lichen.

stage of decay on the highway side, or on the walls of an old ruined barn in the corner of a meadow. The writer remembers once to have found a rare species, new at that time to the British Flora, on an old decayed boot lying in a fallow field. Having gained the most rural spot within his reach, it will be well to look out for an old tree, an ash if possible, and he will find on the bark a number of species which, carefully removed by the aid of a knife and placed in paper, will afford him hours of interesting study on reaching home. *Parmelia saxatilis* or *Ramalina fraxina* may be the first to meet his eye, while, on closer investigation, he will discover *Lecanora subfusca* or *Lecanora varia*, with their abundant apothecia, covering the surface of the bark. Near the base he will probably observe patches of a nearly white crustaceous Lichen, having here and there warty protuberances, with openings in the centre, revealing to a close inspection an almost concealed hymenium—this will be *Pertusaria fallax*. We cannot pretend to enumerate the various species that will reward a careful examination of such a tree as the one we have supposed, but we would advise the collector to secure a fair specimen of all species he can find, for although he may obtain nothing very rare, he will obtain sufficient with which to begin his study. If he can get into the vicinity of rocks which have been exposed to the weather for a long period, or old stone or brick walls, he will not return empty-handed, for a vast number of species find their home on such surfaces as are presented by these. Wherever the tint of colour differs from the natural colour of the rock we may reckon on finding a Lichen. The artist produces his picture by the skilful combination of inorganic pigments—not so Nature—she produces the effects we admire by the aid of highly-organised vegetable growths, and we may rest assured, if we see the bark of trees or the surface of rocks presenting shades of brown, green, or yellow, they arise from the presence of the objects of our search. Within the compass of a square yard a dozen species of Lichens may be flourishing in all their beauty. If the search happens to be on a rocky sea-coast, the student will probably find some of the *Ramalinas* above the line of high-water mark, such as *R. polymorpha*, *R. scopulorum*, or *R. cuspidata*. He will probably find also some of the *Roccellas*, as *R. tinctoria* or *R. fusiformis*, and if his search be pursued lower down on the rocks, washed by the waves, he may find the curious little *Lichina pygmæa*, which resembles a miniature seaweed, but is a true Lichen; and the dark olive green *Verrucaria maura*, which looks, at a little distance, like a coat of paint. Inland rocks, except they be of the very softest nature, will afford innumerable species of interest to the collector. Slate rocks are rich in those splendid species, *Parmelia caperata* and *Physcia parietina*, and the striking variety of *Parmelia saxatilis*, called *omphalodes*. Limestone rocks abound with the brilliant specimens of *Placodium callopismum* and *P. murorum*, with *Lecideas*, *Verrucarias*, and other interesting species. Nor will the earth itself fail to yield a goodly array of *Cladonias*, *Cetrarias*, and *Lecideas*. In fact, whenever the pocket lens is brought to bear with judgment on rock or tree, or hedge-bank, some species will reward the search.

Here it may not be out of place to offer a few hints on *collecting Lichens*.

Select well-grown and complete specimens. I have seen some men contented with a mere fragment of a specimen, destitute of any apothecia, and showing nothing of the margin, where often much of the distinctive character of a species lies. It is as though a single stone from a house would serve to show the style of architecture. It is quite true that some species are rarely found in fruit, but this is the exception rather than the rule.

Collect every species with which you are not acquainted. By doing this much rubbish may be taken home, but it is easily disposed of, whereas good specimens may be passed over which no other opportunity may ever present for collecting. The most advanced Lichenologist often finds in his vasculum at the end of a day's excursion much which home examination proves to be of no value, while some specimen he thought but little of when he gathered it is the gem of his day's work.

Fold up each specimen in paper, and write on it date and locality of growth the moment it is gathered. Some species are very delicate, such as *Caliciums* and *Coniocybes*, and would be destroyed by the rubbing of others against them; but all are the better for protection. The importance of recording on each the locality will soon be discovered, by the additional advantage it gives to specimens, besides being a contribution to the Flora of the district.

Remove as little of the rock or tree as is consistent with obtaining a good specimen. Facility in using the hammer and chisel will only be acquired by practice and a few bruises of the hand. When the cleavage of the rock favours the operation of removing specimens all is well, but in cases where igneous rock has to be dealt with, or where the Lichen grows on the edges of the laminæ, considerable difficulty will be experienced. Let it be borne in mind that a succession of steady, smart taps will accomplish the object more successfully than one violent blow, whether the rock be hard or soft. In removing corticolous species less skill is required, but if the collector should cut too deep into the tree he may discover himself to be the object of a pursuit by the owner of the property, quite as earnest as that he has himself shown after the Lichens.

Taking for granted that a fair collection of Lichens has been secured, and that attention has been paid to the hints given above, the student will now direct his steps homeward, where he will require a few directions, with which I shall conclude my paper, on *the home study of Lichens*.

In the home study of Lichens, not the least important subject we have to dwell upon is the application of chemical tests for the determining of species.

That certain Lichens contained colouring matter which could be made available for dyeing cloth is a fact that has been made known for many years, indeed some authors have gone so far as to say there are allusions to the blue and purple colours procured from them for this purpose in the Bible, (Ezekiel xxvii., v. 7,) but it is only within the last twenty years that Lichenologists have sought to turn this character of Lichens into a means for distinguishing species. A solution of iodine was found, when applied to the hymenium of certain species, to yield a blue reaction, while in other species it merely yielded a vinous brown colour. The blue colour is attributed to the presence of starch in minute quantity in the gelatinous matter pervading the hymenium, called by Nylander the *gelatina hymenia*; or if the colour be produced in the membrane of the ascus and the cell walls of the paraphyses it is attributed to the presence of cellulose in these bodies. The medullary layer of the thallus of some species also gave this blue reaction. At one time this reaction was not only considered of service in separating species, but was even thought to afford a certain criterion by which to distinguish a Lichen from a fungus. Dr. Nylander, however, pointed out in 1865 that many fungi belonging to the section *Discomycetes* gave a similar reaction. Although it thus proved fallacious for this latter purpose, it has continued to this day to be used as an auxiliary help in determining species. Apart from the reaction iodine occasionally gives, it is found to be a most useful substance as a staining fluid for the purpose of bringing out points of structure under the microscope that without some such aid would be invisible. The mode of using it is to place a drop close to the margin of the covering glass under which a section lies on the glass slide, when it will immediately spread by capillary attraction through the whole of the section. Care should be taken, however, that the section has been moistened by pure water only, as any other chemical may interfere with the result.

In 1866 Dr. Nylander proposed two chemical substances capable of affecting the colouring matter of Lichens, as a test by which to distinguish certain closely-allied species, of far greater value for this purpose than iodine, namely, hydrate of potash and hypochlorate of lime. The Rev. W. A. Leighton, and other leading Lichenologists both in this country and on the Continent, at once accepted them as affording most important criteria. Their employment at the present time is all but universal, and hence it is absolutely necessary the student should be put in possession of such information as will enable him to apply them. We will take them in order.

Hydrate of potash is composed of equal weights of caustic potash and water, and should be kept in a stoppered bottle of green glass. For the sake of brevity, in describing its effects, the symbol K is used to represent it, and this letter should be conspicuously written on the label in addition to the name of the mixture.

Hypochlorate of lime is formed by mixing chloride of lime—the common bleaching powder of commerce—with water. The water takes up but a very small quantity in solution, the surplus falling as a sediment to the bottom of the bottle. As this solution will lose its effect if kept for many days, it is best to make a fresh solution every week. The symbol for this is C, which, as in the case of the preceding mixture, should be conspicuously written on the bottle containing it.

For each of these chemicals a separate small brush made of spun glass, procurable at any analytical chemist's, must be used when applying them to the Lichen, and a small quantity of each must be poured from the stock bottles into separate concave watch glasses, small egg cups, or any suitable vessel made perfectly clean for the purpose. Apply with the glass brush to the thallus of the Lichen to be tested a drop of hydrate of potash, and note the resulting colour, if any, then immediately apply in the same manner to the same spot a drop of hypochlorate of lime, and observe the effect. Proceed in the same manner to test the medullary layer of the thallus, for which purpose a small portion of the cortical layer should be carefully removed by scraping it with a knife. The results should be recorded on the paper bearing the specimens by the aid of the following symbols.

The hydrate of potash may produce a yellow colour, the symbol for which is K + ; or it may only be a faint yellow, in which case it should be written K f +. If the yellow tint changes almost immediately into red, the symbol is K yellow then red. Should the yellow produced by the hydrate of potash change into a *deeper* yellow when the hypochlorate of lime is added it will be denoted thus—K yellow, C deep yellow. Sometimes, however, the addition of hypochlorate of lime produces a red colour, which must be written thus—K yellow, C red. Should the hydrate of potash produce no colour, but, by the addition of the hypochlorate of lime, a red colour is produced, the symbol is K—C + red; but if a yellow is produced it is K—C + yellow. Should neither re-agent produce a reaction it is indicated thus—K—C—. Let us suppose, however, that a reaction takes place in the medullary layer, but not in the cortical layer, it will be then shown thus—K $\mp$, that is, the effect on the cortical layer, which in this case is negative, is indicated by the upper sign; and that on the medullary layer, which is positive, by the lower sign. Every possible chemical reaction given with these two re-agents may be thus expressed in a brief and convenient form, facility in the use of which can be acquired in a very short time.

The next important step is to ascertain the microscopical characters of the apothecium. The number, size, shape, and internal structure of the spores; the presence or absence of paraphyses; the colour of the hypothecium, if it be a Lecidea, together with any striking feature that can be detected, should be carefully noted. Diagrams of the spores and their micrometrical dimensions are of great value, and if made on the paper bearing the specimens, it obviates the necessity of repeating the work when subsequently referring to the specimen, as will often have to be done in the course of future investigations. An excellent plan pursued by some botanists is to prepare a microscopic slide of each specimen, to be placed in a cabinet of convenient form for holding a series, arranged in the same order as the specimens in the herbarium. Such a collection will save an infinitude of trouble, for, although a diagram of spores, &c., will be of great use, the inspection of a well-prepared slide will satisfy the mind of a critical worker on points that no diagram can adequately represent. When we say a well-prepared slide, we do not mean to convey the idea that it should of necessity be such a slide as would satisfy the fastidious taste of a *dilettante* micro scopist, though there is no objection to such slides, but we mean that it should clearly display the essential parts of the object under examination, a quality that may co-exist with a certain rudeness of finish in varnish and ornament. We will here lay before the student a few practical directions for preparing his slides, as in so doing we shall be able to convey incidentally some information on other practical points in examining specimens.

Cutting Sections is a delicate and difficult operation, on which much depends in seeing clearly the structure. The excellence of a section consists in two things—first, being sufficiently thin to allow of transmitted light passing easily through all parts, so as not to require so much pressure as would derange the relative position of the various parts; and second, it should embrace the whole, or as much as possible, of what is required to be seen, so as to render unnecessary a second section being made. If the object were to mount a large number of slides, a good section cutter should be obtained from some respectable optician. All, however, that is required where a single section is to be made can be accomplished with a small dissecting knife, having a thin, penknife edge, with a fine point. A watchmaker's eye-glass, having a lens of 1in. focus, held to the eye by contracting the muscles of the face, or, when this cannot be done, supported by an elastic band passing round the head, will be found convenient in making a section, as the two hands are left at liberty for work. Should it be the apothecium of a Lichen that is to be examined, the Lichen is held in the left hand, and a clean perpendicular cut is made near the middle of the apothecium, and the portion nearest the eye is removed, so as not to obstruct the sight, when a second cut is made parallel with the first, by which the thinnest possible section is obtained. Success will not reward the student till several apothecia are destroyed. He must practice, therefore, on some common species. When a sufficiently thin section is obtained, let it be placed on a glass slide, if for present examination only, in a drop of hydrate of potash, which loosens the parts to be examined, making them more transparent; but if for mounting permanently, in a drop of clean water, as the "medium" used for mounting would be injuriously affected by hydrate of potash. Placing the covering glass over the section, and subjecting it to moderate pressure, it is now ready for examination. The magnifying power best adapted for Lichens is, as already stated, one of about 350 to 400 times linear.

A Medium for Mounting Specimens should be at hand in case the section is exceptionally good, or the specimen too valuable to admit of more than one section being taken from it, in which case it can be at once permanently mounted. A very useful medium is that prepared by P. Aylward, of Manchester, which requires to be warmed to render it liquid; and on cooling is sufficiently firm to admit of the surplus being washed off from around the covering glass, which is held in its place by a light clamp. One serious defect of this medium is that it does not preserve the colour of the chlorophyll in the gonidia. The slide should now be finished off, as directed in the ordinary works on microscopic mounting.

Microscopic Measuring of spores is such an important clue to the identification of species that it cannot be altogether passed over here, although, for fuller details, we must refer the student to works treating specially on the use of the microscope. Several methods are in use, and each worker will prefer his own; but, if the student is starting *de novo*, we would recommend the method we ourselves use, which is as follows:—Procure a stage micrometer, ruled for one-thousandths of an inch, or of a millimetre, whichever is intended to be adopted, and, placing it on the stage of the microscope, under the object glass, place at the same time a sheet of white paper at an equal distance from the eye, which will be about nine or ten inches, on a board adjusted for the purpose. Having done this, look down the tube at the micrometer scale with one eye and at the sheet of paper with the other simultaneously, when the image of the micrometer will be thrown on the paper, and lines may be made on it corresponding with those of the micrometer. The first will be a rough copy, and should be revised, by accurately ruling the divisions on the margin of a piece of white cardboard. When this scale has been successfully made, the stage micrometer can be dispensed with as no longer necessary. The scale will be kept close at hand, and will be used as follows:—Supposing the object to be measured be a spore under observation, a diagram should be made in precisely the same manner as the scale was made, namely, by looking with the disengaged eye on a blank piece of paper, and sketching the image thrown on it. When the sketch is completed, and ascertained by repeated trials to correspond with the apparent size and shape of the spore, the scale can be applied to it with ease, and the dimensions ascertained. A separate scale must be made for each power used.

The scale usually adopted in this country is the divisions of an inch, while the rest of Europe adopts the divisions of a millimetre. We prefer the latter, as most Lichenologists use it, besides which fewer figures are required to denote the quantities; thus, if we require to write the dimensions of the spore of *Placodium murorum* (Hffm.) in millimetre, we do it thus:—·011 – ·014 × ·007 – ·008 mm.; while, if written in divisions of an inch, it is written thus:—·00033 × 00045 × 00027 – 00031in.

Supposing the student to have mastered any difficulties he may have thus far met with, he will have acquired so complete a knowledge of the plant he may have under examination at this stage, that he will be in a position to assign it to its place, and append to it its proper generic and specific name. That he will meet with difficulties there can be little doubt, but we advise patience, diligence, and care, before which the most formidable must disappear, and without which nothing worth doing in this world can be accomplished.

ON THE STRUCTURE AND LIFE-HISTORY OF VOLVOX GLOBATOR.

BY A. W. WILLS.

[*Read before the Society, May 18th, 1880.*]

No single organism in Nature has more frequently excited transient feelings of admiration or interest than *Volvox globator*. In the household or at public displays of microscopic objects, none more often elicits expressions of wonder and delight. The exquisitely pure green of its translucent spheres, their inimitable symmetry, and, above all, the perfect grace of movement in a group of these plants, gliding hither and thither with a methodical and stately rotatory motion, passing and repassing, threading their way between one another, the easy regularity of their courses never interrupted by collision, but only checked for a moment when they approach too nearly, and then instantly resumed; in addition, the entire absence of any apparent actuating force to account for this motion;—all these things combine to make Volvox an object of unsurpassed beauty and of perennial delight. Indeed, the microscopist can offer *no* more attractive spectacle than that of a group of Volvox-spheres, young and old, seen under a low power of his instrument, by a well-adjusted dark back-ground illumination.

Yet it is an undoubted fact that the details of their more intimate structure are unknown, even to the majority of professed microscopists,

References to Plate VII.

Fig. 1.—Mature Volvox sphere, showing daughter-spheres within, these also containing the enlarged gonidia, from which spheres of the third generation are to be derived; also showing hexagonal structure and connecting threads.

Fig. 2.—Portion of Volvox sphere treated by glycerine, after Williamson.

Fig. 3.—Portion of Volvox sphere after treatment with solution of aniline purple.

Fig. 4, *a* to *e*.—Development of young Volvox from selected gonidia within the parent; *a* to *e*—the same seen in section.

Fig. 5.—Probable section of portion of living Volvox, after Williamson.

Fig. 6.—Volvox ruptured under pressure, and treated by aniline purple, showing radiating streaks of primordial utricle, &c.

Fig. 7.—Portion of cell wall, showing the pores through which the cilia protrude.

References to Plate VIII.

[The figures in this plate are drawn from a paper by A. W. Bennett, Popular Science Review, July, 1878.]

Fig. 1.—Monœcious Colony of Volvox, showing *a*, *a*2, Antheridia; *a*3, Antherozoids; *b*,*b*2, Gynogonidia; *b*3, *b*4, Oospheres.

Fig. 2.—Complete Antheridium.

Fig. 3.—Oosphere penetrated by Antherozoids.

Fig. 4.—Fertilised Oo-sphere, or Oo-spore.

Figs. 5, 6.—Antherozoids.

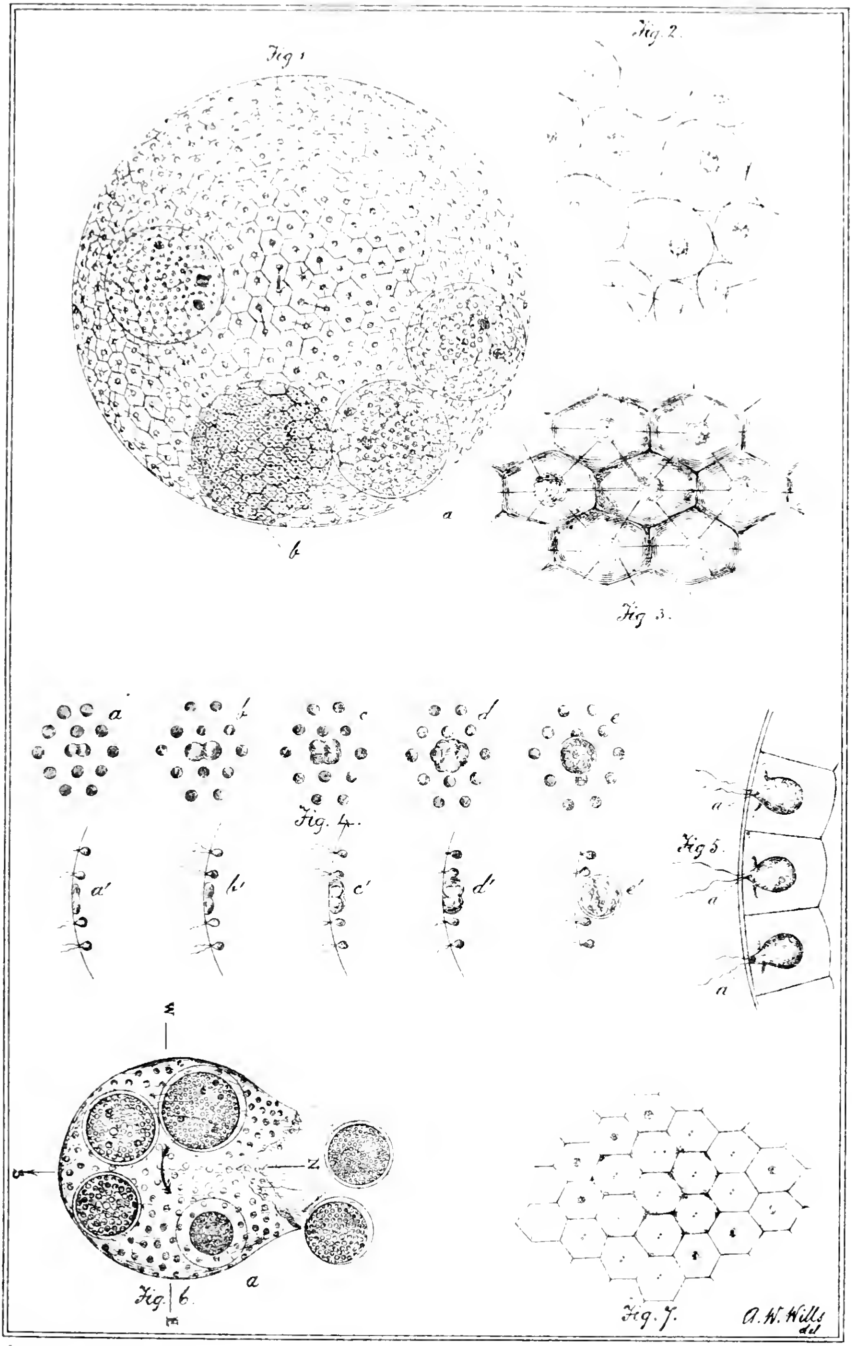
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Fig. 2
Fig 3.
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Fig 5.
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chiefly, no doubt, because they can only be revealed by the careful use of somewhat high powers, assisted by the action of various re-agents.

Finding that the descriptions given in ordinary text-books were often too meagre to be of much value, and as often hopelessly obscure, I was led to consult carefully the original memoirs of Cohn, Busk, Williamson, &c., on this subject, and, wherever it was possible, to repeat their observations—and having acquired by this means a far clearer idea of the structure of Volvox than I had hitherto possessed, having also, perhaps, added some few new facts to the common stock of such knowledge, I have thought that a short summary of what is known of its life-history might be of some use to my fellow-students.

It seems hardly necessary to describe the normal aspect of this organism. Briefly, under a low power, it is seen to consist of a spherical globe of mathematical perfectness, so transparent that, as it glides along, any object over which it passes is clearly visible through its vacant spaces, *i.e.*, through such parts as are not occupied by the structures presently to be noticed, while by focussing the binocular on the lower half of the plant, the effect is obtained of looking into the inside of a glass sphere of crystalline purity and of absolute symmetry. The diameter of a full-grown individual is usually about 1-60″, and individuals are to be found in each colony varying from this down to about 1-180″. The *inner* surface of the sphere is studded at intervals with dark green points, not disposed irregularly, but so arranged that each is usually the centre of a group of six others, placed at the extremity of nearly equal radii. These green points are "*gonidia*," each probably endowed with the potentiality of becoming a perfect Volvox, though only a certain number of them actually undergo that sequence of changes which results in their becoming fresh individuals resembling the parent sphere.

Each gonidium is either spherical or pyriform, (in which case its pointed end is directed outwards,) and contains, in its early stages at any rate, one or more contractile vacuoles disposed among a mass of granular endochrome, and stated by Busk to pulsate rhythmically once in about forty seconds. (Plate VII., Fig. 5.)

At this period are also to be seen in the body of the gonidium one two, or three—occasionally even more—brilliant colourless spots, from one of which is probably derived a nucleus which can be detected by the use of re-agents at a later period.

There is also often lodged within the substance of the zoospore a brown or red "*eye-spot*," and all the eye-spots in an individual look, so to speak, one way. (Plate VII., Fig. 5*a*.)

The apex of each gonidium is more or less produced into a transparent point, from which proceed two cilia, several times as long as the gonidium itself, which pass through two minute pores in the outer cell wall, and move freely in the surrounding water. I am fortunate in having mounted a specimen of Volvox, in which these pairs of *foramina* are clearly shown, and the regularity of their disposition at a uniform angle to the equator of the sphere is striking. (Plate VII., Fig. 7.) It is, of course, by the combined action of these numerous pairs of cilia that the whole organism progresses. Of the direction of the resultant motion we shall speak shortly.

Viewing the surface of the sphere with its convexity presented to the objective, we find, by very careful adjustment of light, that from each gonidium there runs to each of the six surrounding ones a fine thread, sometimes double, occasionally triple, always of extreme tenuity. (Plate VII., Fig. 1;) of *such* tenuity, indeed, as to be frequently invisible; but as the use of certain re-agents often brings these lines into view where it had been previously impossible to detect them, and as they may be sometimes discerned for an instant when the eye is applied fresh and unfatigued to the microscope, where even a moment later they seem to be absent, it may be assumed that the structure is universal, though often far too subtle to be detected. It is needless to say that no skill of the draughtsman can even suggest its infinite delicacy, while the figures given in books, not excepting the beautiful drawings in Ehrenberg's "Infusionsthierchen," exaggerate the strength of the connecting lines to the extent of grossly caricaturing the extreme fineness of Nature's own handiwork. As I sit writing to-day, the afternoon sun of an exceptionally bright day, shining full on my study window, reveals the presence on the outside of the panes of a few spiders' webs, so fine that it is only as the breeze causes them to sway gently to and fro that they shimmer into visibility. When I rise from my seat, and try to discover where they cross the window, they are absolutely gone from my sight. If you will picture to yourself a tiny green bead, surrounded by six others, and disposed upon the outside of this same window, and each connected with its neighbours by one of these fine spider-threads, I do not think the combination will give an exaggerated idea of the superlative delicacy of the network of "protoplasmic threads" with which the surface of a Volvox sphere is diapered.

To return to the gonidia and their history.

A certain number of these in each individual are selected to produce a group of young Volvoces within the parent sphere. The books fix this number as usually four or eight; but out of twenty-five individuals now in the field of my microscope, I find only three containing four incipient spheres of the second generation, while only one contains eight, and there are four containing five, six with six, ten with seven, and one with nine such progeny. Almost every Volvox, when first discharged from the parent sac, and possessing a diameter of about 1-170″, already contains a certain number of enlarged gonidia, destined in due time to become its own progeny. Not only so, but long before its discharge, and while yet it exists as a daughter-cell within the protecting cavity of the parent generation, these selected gonidia are already visible as spots larger and darker than their fellows. (Plate VII., Fig. 6.)

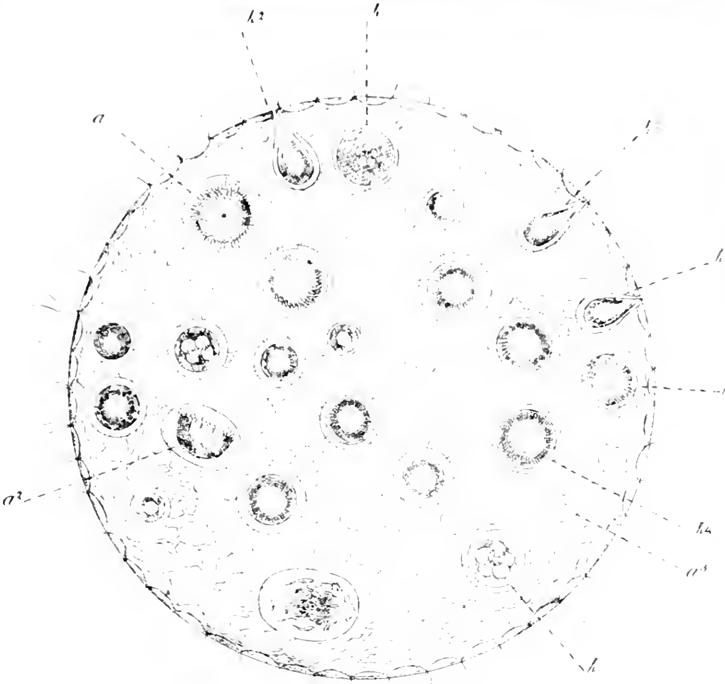
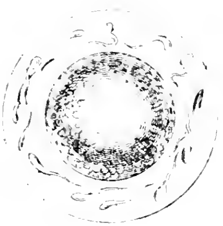


Fig. 1.



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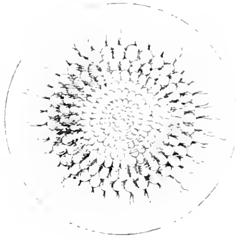


Fig. 2.

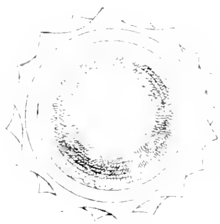


Fig. 4

Fig. 5.

Fig. 6

The history of these selected gonidia, as it may be traced in a daughter-sphere recently cast forth to seek its fortunes in the world of waters around it, is as follows:—The enlarged gonidium is at first a flat thin circular disk, appressed to the internal surface of the sphere, and being surrounded by *eight* of the ordinary zoospores, is derived from the coalescence of the two central ones out of a group of ten. (Plate VII., Fig. 4*a a′*.) Shortly, this disk assumes a more distinctly oval form, with a slight constriction across its lesser diameter, in which stage it often much resembles a young Cosmarium. (Plate VII., Fig. 4*b b′*.) It is soon seen to be clearly sub-divided into four, and its thickness having grown *pari passu* with its superficies, the group now protrudes into the internal cavity of the parent plant. (Plate VII., Fig. 4*c c′*.) Repeated sub-division now goes on rapidly, (Plate VII., Fig. 4*d d′*,) till the whole body assumes a spherical form, a distinct cell wall being at the same time formed, which is revealed by careful illumination, and still more clearly by the use of re-agents, as a hyaline sphere concentric to and of larger diameter than the green one within it, so that there appears to be a clear space or ring between the two when seen in section. (Plate VII., Fig. 4*e e′*, and Fig. 6.) Finally, the young Volvox consists of a vast number of deep green granules, closely packed together, and by mutual pressure driven to assume a more or less distinctly hexagonal form, and corresponding in number to the gonidia which are to stud its surface when its growth is completed. (Plate VII., Fig. 6*a*.) Shortly hereafter, the whole organism continuing to increase in size, clear spaces appear between the gonidia, *showing that the enlargement of the cell-wall and its interspaces is outstripping that of the gonidia*, which are now approaching maturity. The interlacing connecting threads are developed simultaneously. (Plate VII., Fig. 1*a*.) During the whole process, the centre of the young Volvox spheres continually recedes from the periphery of the parent, so that when the group of young ones has attained the full development of which it is capable in this stage, they are often pretty closely packed in the internal space, and sometimes even slightly deformed by mutual pressure; each by this time closely resembling the parent in miniature, and already containing enlarged gonidia of the third generation. (Plate VII., Fig. 6.) By this time, the clear space originally visible between the gonidia and the cell-wall has been obliterated, and the cilia may be seen protruding through the latter. Some writers state that the daughter-cells rotate at this period within the parent cavity. I have frequently seen them oscillate so far in one direction, and then back to their original position, but have never observed a true rotatory motion. Finally, the young Volvoces are liberated by the rupture of the parent sac, at a *special point, clearly marked out for this purpose in its structure*. (Plate VII., Fig. 6.) I have not met with any observations on this point, but have fully convinced myself that it may always be predicted at what point this rupture will be effected.

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, and the *point of rupture of the sphere will be at its north pole*. (Plate VII., Fig. 6.

It is difficult to determine precisely how this rupture is accomplished, but I believe it to be by a special contraction of the walls of the parent, or of the invisible primordial utricle, *not* by the outward pressure of the daughter-spheres, this force being evidently inadequate to produce the result where their number is small, whatever it may be when it reaches its maximum.

Shortly before the emission of the young, the cell commonly assumes a slightly pyriform shape, and then slowly opens at its apex, but *the aperture is of less diameter* than that of the young Volvoces, and as each of these passes out, the mouth of the bag is visibly stretched. and resumes its original size after each daughter-sphere has escaped; so that it evidently possesses considerable elasticity, a property also made manifest by the fact that the normal form of Volvox may be considerably flattened by the pressure of a glass cover, and yet resume both its spherical form and its motion when this pressure is removed.

Moreover, the daughter-sphere passes out *without rotating*, and from whatever cause it derives its impulse, this often suffices to drive the young Volvox clear of the mouth of the sac to a distance equal to several times its own diameter, in which position it pauses motionless for some seconds, and then, commencing to rotate gently, sails away, at first slowly, then more and more rapidly, to enjoy its independent existence.

After the rupture of the sac, the gonidia near the edges of the opening are seen to quiver from the action of the cilia where they are partially freed from the support of the surrounding envelope, and the same thing occurs when they are forcibly torn from their attachment, in which case they may even move for awhile freely through the water.

The general action of the cilia continues for some time, and the empty sphere rotates as before, its general direction being still from north to south, with the open end to the rear. After a time, which I cannot specify, the cilia cease to play, and the organism decays, having fulfilled its destiny in life.

The birth of the young Volvoces is affected by various circumstances. Doubtless the process is, under natural conditions, most active in the early hours about dawn, when the analogous functions of similar organisms are well known to be most energetic, but in order to see the phenomenon in full vigour it is only necessary to place a number of mature parent-spheres, such as are found in every colony, in a shallow live-trough, and to bring them into a warm room. In an hour's time almost all the young plants will have been liberated. Light and heat stimulate the action, while cold and darkness retard it. The ciliary action is affected in a remarkable degree by altered external conditions. If a drop of water considerably colder than that in which the Volvoces are floating be allowed to flow in under the cover-glass, the whole are paralysed for some seconds, after which they slowly resume their motion. A sudden mechanical shock produces a similar effect, as I have repeatedly seen to happen in consequence of the rude impact of some ferocious Entomostracon.

A sufficient degree of heat to make the water distinctly tepid to the feel, causes instant and simultaneous death of the whole colony.

During the day the majority of the Volvoces contained in a shallow vessel rise to the surface, although they avoid strong direct sunshine, while at night they retire in a cloud to the bottom.

The astonishing number in which the spheres at times appear in some pool and their equally sudden disappearance, have been frequently remarked. Doubtless a very slight change in external conditions suffices on the one hand to favour the development of countless thousands of young plants, and on the other, either to destroy the vitality of the whole colony, or to drive it to seek refuge in deeper water.

A curious instance of this sensitiveness to varying conditions of light and heat occurred to myself. I had two shallow vessels in a north window, each containing a goodly supply of Volvox. Cold and inclement weather, which prevailed for weeks together, seemed to check their increase, for I found but few young spheres from day to day among the older ones. Thinking that a moderate degree of warmth would tend to increase my colony, I transferred one vessel, fortunately not both, to the floor of a warm greenhouse. In forty-eight hours all were dead, and in a few days scarcely a vestige remained of the countless corpses which had copiously strewed the bottom of the glass.

We must now revert to the minute structure of the mature parent-sphere, which has been exhaustively studied by Cohn, Busk, and Williamson.

In the outset it should be stated that the last-named observer believes that there are two distinct forms of Volvox, in one of which the peculiar structure which I am about to describe exists, while it is absent from the other. Busk disputed the the accuracy of Williamson's observations on this point, but, in an appendix published subsequent to the body of his essay, he states that he has detected this same structure in specimens from Manchester, but *not* in his own.

I have failed to develop it by the means recommended by Williamson, but have succeeded in making it evident enough in a great number of specimens from Sutton, by the use of other re-agents, and especially by the application of aniline purple, an invaluable auxiliary in the examination of minute vegetable cell-structures.

This substance stains the protoplasmic elements of such structures to a colour which appears deep purple by direct light, and crimson by dark back-ground illumination, and reveals details which are wholly invisible without its use.

The colour is, however, greedily absorbed by some of the materials used by the microscopist, so that a judicious choice of these is necessary to ensure success. Objects stained in this manner are, for instance, rapidly bleached if mounted in gold size cells, and I have for the present adopted zinc-white in its place. Among other re-agents which I have used are eosin, iodine, iodised glycerine, carmine solution, potassium permanganate, nitrate of silver, and other salts, some of which bring into view various parts of the minute structure of plants; but aniline colours, applied with due precautions, produce the most rapid and striking effect.

Professor Williamson describes the structure in question as a network of lines dividing the whole surface into hexagons, in the centre of each of which is seated one of the gonidia.

The delicate "protoplasm-threads" proceeding from each of these to its six surrounding neighbours never pass through the angles of the hexagons, but always through the side of each hexagon to the next gonidium. (Plate VII., Figs. 1, 3.) Hence it appears that "the points of adhesion are chosen prior to the development of the outer cell-membrane," in which light Williamson regards the hexagonal division. In his specimens this structure was developed by immersion in glycerine for some time. I have failed to obtain more than the faintest suggestion of it by these means, but it is often brought out by the application of aniline purple, as is also an important detail shown in drawings made from his preparations, viz., that at the angles of the contiguous hexagons there is sometimes a distinct doubling or separation of the lines, whence he concludes that each side of the figure is really formed by two delicate cell-walls in close juxtaposition, the duality of which is only made evident by the action of re-agents. (Plate VII., Fig. 2.) He regards the globe of Volvox as a "hollow vesicle, the walls of which consist of numerous angular cells, filled with green endochrome, &c., the intercellular spaces being more or less transparent," and the ciliated zoospore as representing the endochrome of a cell having two walls, the *internal* one being separated from the outer cell-wall, except at a few points where it is retained in contact by the connecting filaments, and the *external* one forming the hexagonal divisions on the surface. He further holds that the periphery of the sphere, when seen in section, has an appreciable thickness, its inner margin being definite and parallel to the outer one; and that the sides of the hexagons being continued downwards through the thickness of the outer membrane, the appearance of all these structures, if they could be seen simultaneously, would be that shown in Plate VII., Fig. 5.

Even in deeply-stained specimens I have never been able to detect the existence of these hexagons as other than an entirely *superficial* structure, and at present my impression is that the hexagonal structure has a different significance.

In the very early stage of Volvox-life, the embryo gonidia are encased in a distinct transparent outer-sphere. (Plate VII., Figs. 4*e* and 6.) At a later period, owing to the more rapid growth of the gonidia than of the case, the latter closely invests the former, which are, in fact, embedded in it. In the next stage, if not in the earlier condition, by the continued growth of the gonidia at a *greater rate* than that of the containing sphere, they are so closely appressed as to assume the hexagonal form, and the interstices must, of necessity, consist of a thin film of the substance of the containing spherical envelope, moulded, so to speak, into corresponding forms. But now the diameter of the young Volvox, which is, by this time, sent forth on its independent career, rapidly increases, the gonidia assuming their spherical or pyriform shape, as their mutual pressure diminishes, and being hourly separated by greater intervals. If now the actual formative matter of the sphere receives no further, or only a disproportionate increment, but is gradually attenuated by continued expansion, as a soap bubble is distended by blowing into it, the hexagonal lines into which it has been moulded by the previous mutual pressure of the embryo gonidia will be gradually stretched in all directions into finer proportions; and just as this figure is that which is *necessarily assumed* by a number of spherical bodies under mutual pressure, *so* the most economical disposition of this particular part of the Volvox-structure will necessitate its constant attenuation into hexagons of ever-increasing delicacy. (Plate VII., Figs. 1, 3, 7.) If the process be continued long enough, it may finally result in the structure becoming too filmy to be detected by any microscopical observation; and it is worth noticing that it is usually in spheres of small or medium diameter that the hexagonal divisions can be developed, and not in those of the largest size. Such appears to me at present to be the rationale of the formation of this structure.

The internal cavity of the sphere is said to be filled with a "mucilaginous fluid." If a Volvox be ruptured under a cover-glass, and aniline purple introduced by capillary attraction, the colour seems to be for awhile repelled at that part which is in front of the rupture, and to flow round it on either side. It is only after a considerable time that it gradually penetrates this space, and brings out, by staining it of a deep purple tint, a mass of hazy matter, from which proceeds streaks or lines, radiating more or less regularly from its south pole. (Plate VII., Fig. 6.) This structure, to which I do not think attention has been hitherto called, is also sometimes developed in deeply-stained specimens within the slightly ruptured sphere, and seems to show that there is a denser layer of thick matter, whatever its nature may be, disposed in a somewhat regular manner, being concentrated near the south pole of the axis of rotation, whence it spreads over the inner surface in streaks resembling the lines of longitude on a terrestrial globe.

Both from its position and from the rapidity with which it is stained by aniline purple—without which its existence is apparently absolutely undemonstrable—(in which respect it is in marked contrast to the outer cell-wall, which latter is only faintly tinted by somewhat prolonged application of the re-agent, and then only where the hexagonal structure exists,) I have no doubt that this inner layer is the true "primordial utricle" of the cell, and possesses that character of vital and formative matter which distinguishes this element of cell-structure from the outer wall, which, on the other hand, probably consists of cellulose or some similar compound. Probably the arrangement of this inner layer in radiating lines or ribs contributes to the elasticity of the fabric, whereby it is enabled to open at a given point for the escape of the young, and to contract again after their emission.

The increase of individuals by the means already described is strictly an instance of subdivision.

But Volvox Globator also affords an instance of true alternation of generations. As may probably be affirmed of all living organisms, its 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 awhile, and, like the zygospores of the Conjugate Algæ, to resist vicissitudes of condition and climate through the rigours of winter, and then to reproduce the parent-form in the succeeding year, when external conditions again favour its development.

Cohn first fully traced the various stages of this process, and described them in the "Beiträge zur Biologie der Pflanzen," 1875, Vol. I., Heft 3, and in the "Annales des Sciences Naturelles," 4 ième Ser. Bot; Tom. V. 323; and his observations have been more or less confirmed by other investigators, especially by Carter, Ann. Nat. His., 3rd Ser., Vol. III., 1859, p. 1, and more recently, in 1877, by a French botanist, M. F. Henneguay.

Cohn and Carter both hold that there are two varieties of Volvox, one monœcious, the other diœcious, and the latter maintains that Sphærosira Volvox is the male form of the diœcious sub-species. Be this as it may, the reproductive process in the monœcious form is as follows:—The sexual reproductive cells, male and female, occur in spheres of unusual size in the autumn, and are few in proportion to the number of sterile cells, and the reproductive process does not occur simultaneously with, but as a climax to a long series of asexual generations. On their first appearance the gynogonidia or female cells are about three times the size of the sterile ones, of a deep green colour, and of a frothy consistency from abundance of vacuoles; they are easily distinguished from the parthenogonidia by their never subdividing. (Plate VIII., Fig. 1*b*.) They next become flask-shaped, their narrow end touching the periphery of the sphere, and the broader end hanging free in the internal cavity. (Plate VIII., Fig. 1, *b*2.) Finally they assume a spherical form, and become oo-spheres, each enveloped in a gelatinous membrane. (Plate VIII., Fig. 1, *b*3, *b*4.)

The androgonidia or male cells at first closely resemble the partheno-gonidia, but, undergoing division in two instead of three directions, develop into *plates or discs of cells, not* into spheres, and ultimately resolve themselves into bundles of naked elongated cells, in which the chlorophyll is transformed into a reddish pigment, each with a long colourless beak, with a red "eye-spot" and two cilia. (Plate VIII, Fig. 1, *a*, *a*2.) About the same time that the oo-sphere is mature these antheridia begin to move from the combined action of their cilia, (Plate VIII., Fig. 2,) and then break up into separate antherozoids, which finally become free and move rapidly within the cavity of the sphere. (Plate VIII., Fig. 1, *a*3.) Assembling round the oo-spheres, they penetrate the envelopes of the latter, (Plate VIII., Fig. 3,) coalesce with their contents, and the *oo-sphere* thus fertilised becomes an *oo-spore*, which soon develops a cell-wall covered with conical stellate projections, and a second smooth internal membrane. (Plate VIII., Fig. 4.) The chlorophyll now gradually disappears, and is replaced by an orange red pigment. In this condition the oo-spore constitutes the *Volvox stellatus* of Ehrenberg. It is liberated by the decay of the parent-cell, and sinks to the bottom of the water to hibernate. The subsequent history of these bodies has been traced by Cienkowski, and more recently by Henneguay, ("Journal de Micrographie," Vol. II., p. 485, Bull. Soc. Philomath, Paris, July, 1878.)

Cohn believed that they must be dried up before germination was possible. Henneguay has now observed that this is not so. In spring the outer case of the spore (exospore) is ruptured, and the swollen contents (endospore) project through the opening. The contents then divide gradually into two, four, eight, sixteen, or more small cells, which become bright green, each meanwhile acquiring two vibratile cilia while still contained within the inner membrane of the spore. The cells, at first in close apposition, separate further from one another by interposition of gelatinous hyaline matter, the outer membrane disappears, the cilia become active, and the young Volvox, already containing some elements larger than the others and destined, in due course, to produce daughter-spheres, moves freely through the water. "The spores of Volvox, therefore, germinate in water, and each of them produces a single colony by a process of segmentation identical with that which gives rise to a daughter-colony at the expense of a cell of the mother-colony."

The sequence of asexual generations is repeated for many months, and in the following autumn the alternation of generations is again completed by the intervention of the processes just described.

There are other phenomena of more or less exceptional occurrence and of lesser interest in the history of Volvox, to which I might allude did space permit, but those which I have traced constitute the essential elements in the structure and life-history of this singularly beautiful and interesting plant. I trust that I have succeeded in presenting to my fellow-students a somewhat more complete and life-like account of them than is accessible in ordinary text-books, and in showing how amply this organism will repay careful and systematic observation.

ON LEPTODORA HYALINA.

BY W. P. MARSHALL, C.E.

[*Read before the Society, November 18th, 1879.*]

This very interesting Entomostracon has attracted special attention from the circumstance that it has been entirely unknown in this country until the present year, having been previously found only on the Continent; but it has now been found in great abundance in the neighbourhood of Birmingham, at Olton Reservoir and Edgbaston Pool, the only places in this country where it has at present been met with. This little creature is also interesting from its remarkable transparency, which renders the internal structure unusually clear for examination; but this transparency and the absence of colour cause the object to be easily overlooked, notwithstanding its comparatively large size, extending to one-third of an inch in length. The circumstance of its not having been found here before may be partly due to this cause, as well as to the unusual depth below the surface of the water, four feet or more, at which it is found.

Fig. 1, Plate IX., is a drawing of the male Leptodora; and Fig. 2 the female, showing the eggs in the ovary. Fig. 3, drawn to a larger scale, shows the eggs in the external incubating chamber.

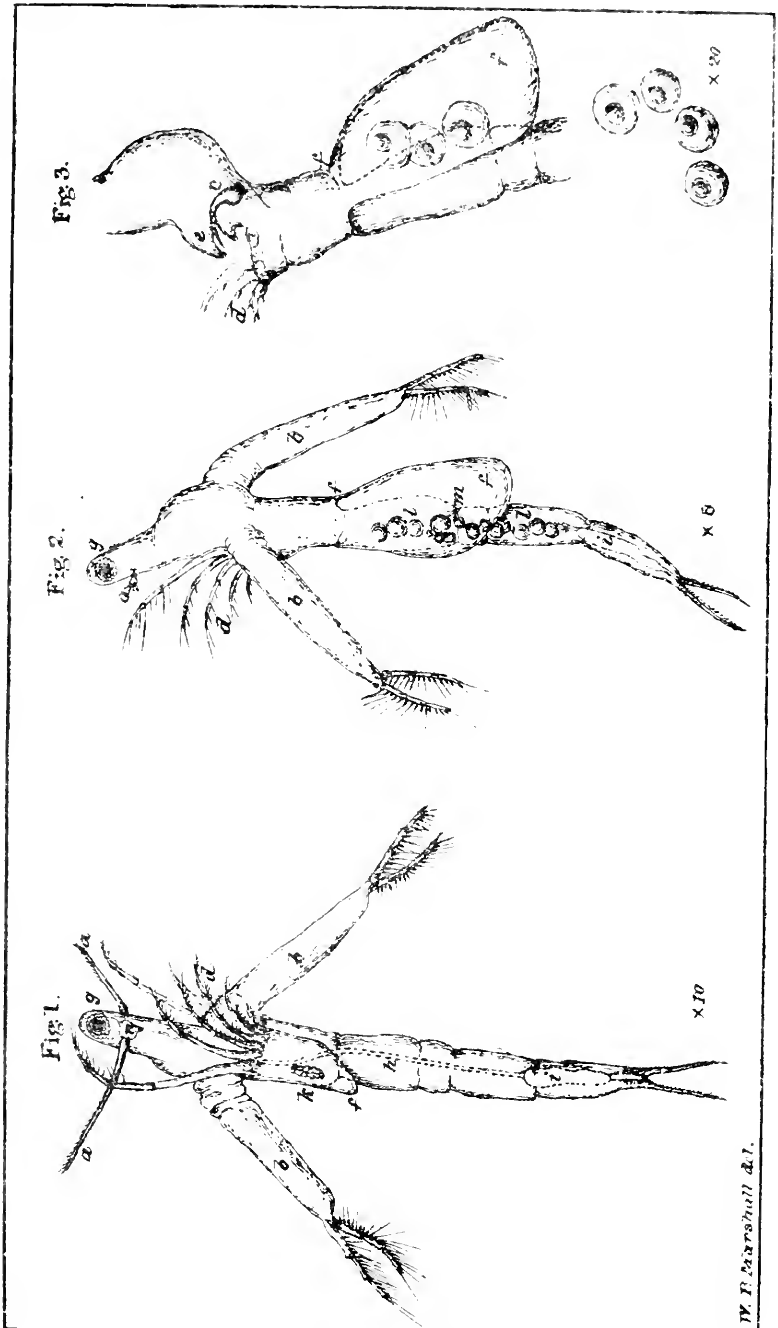
The singular modification in form and structure that is shown in Leptodora from the ordinary Entomostraca is of much interest. The most striking difference in its appearance from such Entomostraca as

References to Plates IX. and X.

a.—Anterior pair of antennæ, or antennules.
b.—Posterior pair of antennæ, or swimming arms.
c.—Pair of mandibles.
d.—Six pairs of limbs, or foot-jaws.
e.—Labrum, or upper lip, shown in its raised position by the dotted lines in Fig. 5.
f.—Carapace, forming the incubating chamber in female.
g.—Compound eye.
h.—Alimentary canal, or œsophagus.
i.—Intestine, or stomach.
k.—Heart.
l.—Ovaries.
m.—Oviduct, external opening into incubating chamber.
n.—Brain.
o.—Muscles giving rotation to the eye.
p.—Pair of nerve cords from the brain to ganglia situated above the mouth.

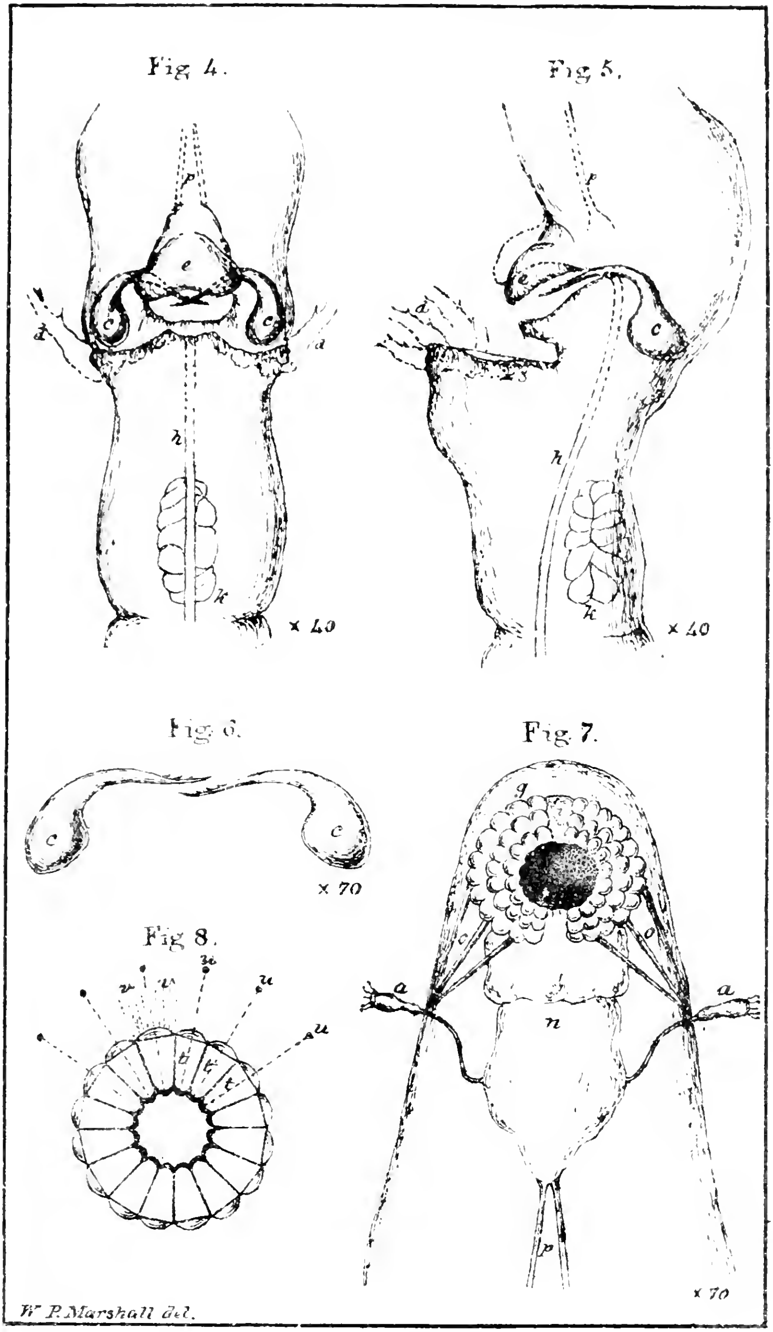
Fig. 1.—Male Leptodora, partly ventral view, showing the eye, brain, heart, alimentary canal, and stomach.
Fig. 2.—Female Leptodora, partly dorsal view, showing the two ovaries, external opening of oviduct, and incubating chamber.
Fig. 3.—Enlarged view of female, showing mandible and mouth, and showing eggs deposited in the incubating chamber.
Fig. 4.—Front view of mouth, further enlarged, showing pair of mandibles and heart.
Fig. 5.—Side view of the same.
Fig. 6.—Pair of mandibles detached.
Fig. 7.—Eye further enlarged, showing division into two hemispherical eyes, muscles giving rotation to the eye, brain, and nerves branching to the two antennules.
Fig. 8.—Diagram illustrating the construction of the eye.

Plate IX.



Leptodora hyalina.

Plate X.



Leptodora hyalina.

Daphnia is that the carapace, which in Daphnia is so large as to enclose the entire body like a bivalve shell, is so much reduced in Leptodora as to present only a small incubating chamber in the female, only partially covering the body, and not more than one-fourth of its length ; and in the male this appendage almost vanishes, and is represented by a mere rudimentary projection. The first segment of the general integument, namely, the head covering, instead of lying close down, and terminating in a pointed beak as in Daphnia, is prolonged upwards in Leptodora, as a tapering pedestal, on the top of which is placed the large single eye. From the next segment of the integument, namely, the covering of the thorax, there is developed the enclosing casing of the incubating chamber, which is the same in structure and origin as the large enclosing casing of Daphnia, being a fold of the chitinous or horny integument which is doubled in upon itself, forming a double hollow wall to enclose the incubating chamber, as shown by the dotted line in Fig. 3. The eggs, when in this chamber, are entirely outside of the body, being between two walls, both of which are external surfaces of the general integument. In Daphnia this double fold is extended so far as to cover the entire body, but in the male Leptodora the fold is shortened so much as to become only a short projecting pouch, not covering the body, as seen in Fig. 1.

The swimming arms, or posterior antennæ, are greatly enlarged and prolonged in Leptodora, and have a remarkable development of powerful muscles. The extreme transparency of the object allows the form and attachments of these muscles to be seen very clearly, and with polarised light they present a singularly beautiful view.

The eye is a large spherical group of lenses, as shown enlarged in Fig. 7, Plate X. It is seated directly upon the brain mass, from the lower portion of which two nerves branch laterally to the anterior antennæ, and a pair of diverging nerve cords pass down to ganglia situated immediately above the mouth. The anterior antennæ, or "antennules," are very short in the female, terminating abruptly with a fringe of knobbed hairs, but in the male these antennæ are long and tapering to a point. The single eye of Daphnia and other Entomostraca was considered by Swammerdam (as quoted by Baird) to be a pair of ordinary hemispherical eyes united into one, but this view was not entertained by subsequent authorities. From the structure of the eye in Leptodora there however appears good reason to conclude that Swammerdam's view was correct; and it will be seen on consideration that such a view has a strong support from analogy. The eye in Leptodora is divided into two lateral halves by an interval at the base, where it is seated upon the brain, and also by a gap left open at the top, but the division at the top does not show in most specimens, and the impression is consequently given that, when the division is shown, as in the specimen from which Fig. 7 was drawn, it is a case of incomplete development, reverting to an earlier type of separate eyes.

The eye has a partial rotation round its centre, as in the case of Daphnia, and the three muscles shown on each side of the eye serve to give this motion. The general structure of the eye, as represented in the elementary diagram, (Fig. 8,) consists of a set of radiating conical tubes or "telescopes," *t t*, furnished each with a lens at the outer end, and a layer of black pigment to receive the image at the inner end; this pigment extending partly up the sides of each tube to separate them from one another, and giving the appearance of a black centre to the whole eye. Now, each of these "telescopes," if it were stationary, would be only suited for seeing distinctly an object in the one direction of the axis of the telescope, as shown by the dotted centre lines, *u u*, in Fig. 8; and other objects that were lying between these directions would be only imperfectly seen, or not at all visible. But, if each telescope, instead of being stationary, is given a range of lateral motion sufficient to take in that space, as shown by the shorter dotted lines, *v v*, there will be a direct vision of every object in succession, and this is exactly the motion that is possessed by the eyes of Leptodora and Daphnia, which constantly roll about through a small range of motion, by an apparently involuntary action. It is now suggested that this is an explanation of that singular motion of the eye, which is only needed in such cases as Leptodora and Daphnia, in which the head is rigidly fixed by the stiff armour-casing that does not admit of any lateral movement of the head for shifting the direction of sight of the fixed eye. In the numerous cases of insects with fixed hemispherical eyes studded with separate lenses, the neck is sufficiently flexible to allow of the head with its fixed eyes being moved about as required for obtaining complete vision in different directions.

The thorax of Leptodora is furnished with six pairs of limbs or "foot-jaws," ranged on each side of the mouth, for bringing food to the mouth; these diminish successively in size from the back pair, which are long and four-jointed, to the front pair, which are reduced to simple palpi. The mouth (drawn enlarged in the front view, Fig. 4, and the side view, Fig. 5) is surrounded by the foot-jaws, and covered by a large hood that moves up and down, forming the labrum or upper lip; the alimentary canal leads direct from the back of the mouth, and passes down in a straight uninterrupted line through two-thirds of the length of the abdomen, and then opens into an enlarged intestine or stomach. There has not been any trace of food observed to remain in this alimentary canal, which appears to act throughout simply as an œsophagus. At each side of the mouth is a curved pointed mandible, (drawn separately in Fig. 6,) each armed with three short barbs near the point, and the base of the mandible is bedded upon a mass of muscle. The pair of mandibles have a transverse movement in the mouth, their barbed ends crossing one another and then separating alternately, with an action similar to the mandibles of caterpillars and other larvæ; the barbs are on the upper side only of the mandibles, and do not interfere with their rubbing together in this movement. This pair of mandibles form in position a continuation of the line of limbs or foot-jaws, and they are to be looked upon morphologically as a greatly modified pair of limbs; in the same way as in the large crustacean, the lobster, one pair of limbs are modified in the opposite direction into the large crushing-claws.

The heart (shown in Figs. 4 and 5) is a large contractile vessel, situated at the back of the thorax, and consisting of a singular ribbed structure, formed in several lobes externally, but not having any divisions internally. It has a regular pulsation of about 150 beats per minute, each contraction appearing to flow upwards as a wave upon the surface of the vessel. The heart has an aperture at each end, but no circulating vessels have been traced from it, nor in any other portion of the body. Although, however, there is not any system of circulating vessels, the circulating particles do not travel promiscuously through the body, but appear to flow in tolerably definite channels in the different parts of the body, in which they can be observed.

The ovaries occupy a great length of the abdomen, extending from near the under side of the mouth to the commencement of the stomach, as shown in Fig. 2. There are two ovaries, one occupying the upper and the other the lower half of that space, and meeting in the centre, where the external openings of the oviducts are situated, at the third segment of the abdomen from the tail end, and corresponding with their position in Daphnia. The eggs are laid in the incubating chamber, formed by the enclosing carapace, (as shown in Fig. 3,) and have the appearance of being secured by means of some adhesive material to the inner wall of that chamber. In a living specimen that I frequently examined under the microscope during several successive days, although the rapid movements of the animal caused the tail end of the abdomen to be violently jerked in and out of the front of this chamber, there was not any motion perceptible in the eggs within the chamber, which remained quite stationary in their original position, appearing to be attached in their places within the chamber. In Daphnia the eggs remain loose and freely floating in the corresponding space of the incubating chamber, but they are prevented from escaping by the tail end of the animal blocking up the open bottom of the chamber, until the time when the hatched young are matured, and these are then allowed to escape by the tail being jerked forward, leaving the chamber open at the bottom. In one mounted specimen (drawn in Fig. 3) that was lent to me by a friend, there were originally seven eggs in the chamber, but four of these have subsequently become detached, and are now floating freely about the cell in which the specimen is mounted, three eggs alone remaining fixed in the chamber; and in this instance it may be supposed that the action of the mounting fluid in the cell has gradually loosened the attachment of the eggs by softening the adhesive material that held them in their places.

Leptodora, though only now discovered in this country, has been known for twenty years on the Continent. It was first discovered in 1858, in a moat round Bremen, by a chemist named Kindt and Dr. Focke; then in 1867 it was found both in Denmark and Norway; and in 1868 in a lake near Kasan in Russia, in Lakes Constance and Geneva in Switzerland, and in Lago Maggiore in Italy. There seems to have been now an interval of eleven years without any record of Leptodora being found elsewhere,* until the discovery of it in this country in the present year by the Birmingham Natural History and Microscopical Society.

* Since the above paper was read, the discovery of Leptodora in twenty-one different lakes of Italy has been announced by Professor Pavesi, of Pavia.

A CHEAP AND USEFUL ENTOMOLOGICAL CABINET.

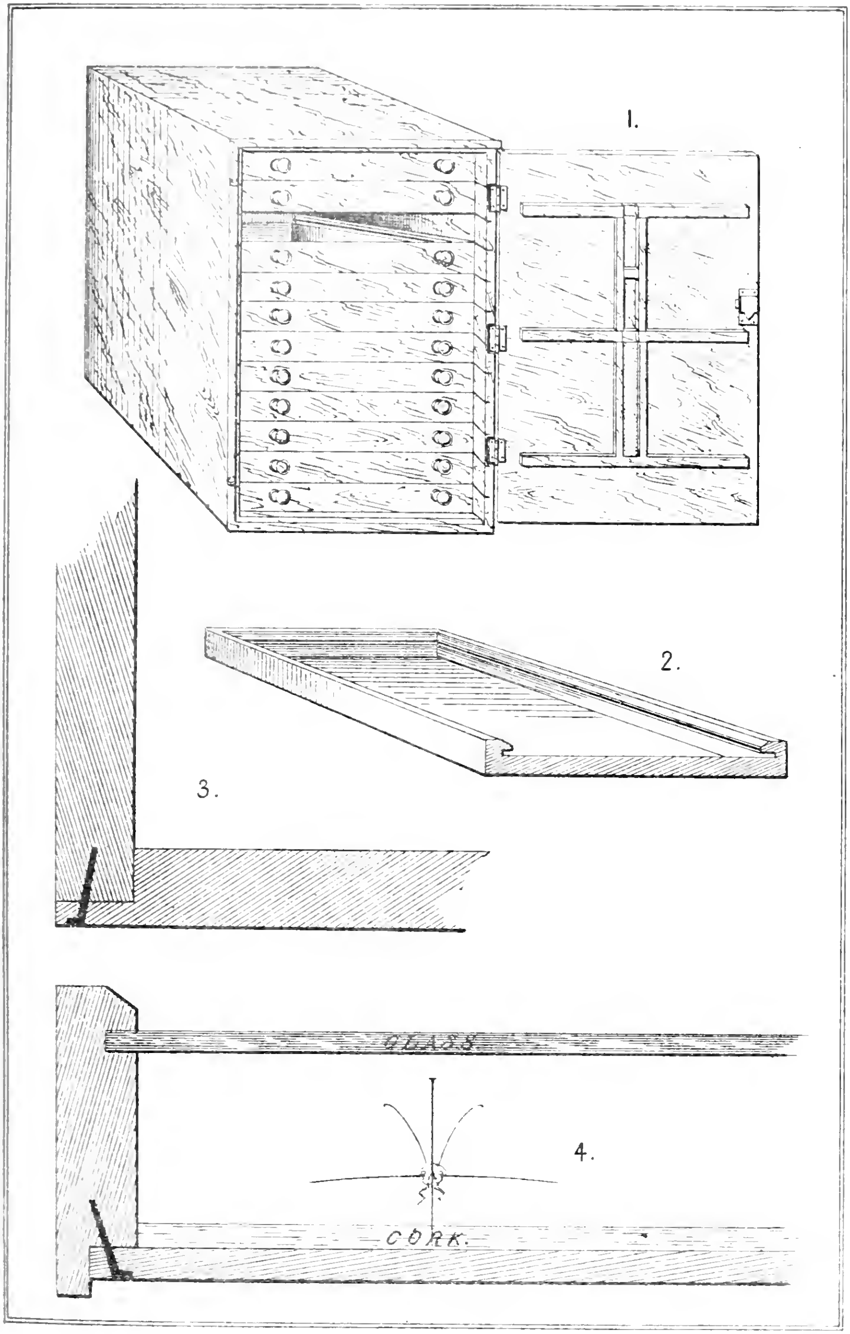
BY W. G. BLATCH.

[*Read before the Society May 4th, 1880.*]

It is said that no one knows where the shoe pinches so well as he who wears it, so no one can enter into or even conceive of the troubles of a would-be entomologist unless he has experienced them. Their name is certainly legion, but like other vexations incident to humanity are best dealt with singly. One of the greatest, as I know full well, is that of providing a safe and readily available receptacle for stowing away and systematically preserving our insect treasures when they have been obtained and duly "set." Of course good cabinets can readily be had by those who have the means and are willing to pay for them, the cost being from ten shillings to a guinea per drawer. But only the comparatively wealthy can afford to indulge in such expensive luxuries. Generally speaking, the most unsuitable receptacles are improvised for storing insects, dust and mites and other enemies find easy admittance into them, and soon produce such havoc that, losing all heart, the collector throws the lot away in disgust, and forthwith abandons both an extremely interesting study and a healthful pursuit. We are not all like Thomas Edward, who, when he lost one collection, manfully set about forming another, but we have most of us had experiences similar to his when he lost his valuable collection of plants for want of a suitable receptacle for storing them. Now it is curious but true that matters of the first importance are left for consideration until last. The boy first catches his bird before he thinks of a cage to put it in, and the entomological tyro hunts for insects long before he seriously considers what he shall preserve them in. No doubt this must always be the case to a considerable extent, but yet it is beyond question a wise course to provide a suitable stable when you are about to buy a horse.

In Entomology, as in most other things, a good deal depends upon the way you start, as to whether you will succeed or fail in the end. I would have the young entomologist begin well, and he can only do this by having something to store his insects in, in an orderly manner, before he accumulates many specimens. It is of importance also that the "something" should not be too large or too expensive, and that it should be capable of growing with the collection. I have come to the conclusion that a cabinet is the only thing to be used, and that it is possible to provide a really serviceable article at a very small cost. With the help of Mr. T. B. Taylor, who has kindly had the accompanying sketches drawn on stone, I have worked out an idea for an inexpensive cabinet that any schoolboy could make for himself (improving upon the suggestion as he pleased) during his long Midsummer or Christmas holidays.

Figure 1 on the accompanying plate (XI.) shows the little cabinet complete, as made with twelve drawers. The size of it is—height $20\frac{1}{2}$ inches, breadth $14\frac{1}{4}$ inches, depth $19\frac{1}{4}$ inches; it is made of white pine,



Entomological Cabinet

⅝ inch thick throughout (one inch would of course be better, but the idea has been to keep down the cost.) The door has three horizontal and two upright stays, the space between the latter being utilised as camphor cells, with sliding plate of perforated zinc in front. The drawers run on metal slips fixed in the sides of the cabinet, and the whole thing is finished with black varnish. Figure 2 shows a drawer as seen from the back, and figures 3 and 4 indicate with sufficient clearness the working details. The latter show sections of the drawers of the full size. The sides of the drawers are grooved for glass, which is made to run in at the back of each. The size (inside) of the drawers is as follows: seventeen inches in length, 12½ inches in breadth, and 15-16ths of an inch in depth between the groove for glass and the bottom, the extreme depth outside measurement being 1⅛ inches. It will thus be seen that in this little cabinet there is not the smallest loss of space or waste of material. Of course, "long" pins cannot be used, but the Nos. 7, 14, and 8 of Kirby, Beard, and Co. will work in well, and for any cabinet these are the best to use for ordinary purposes.

One of these cabinets (twelve drawers) would hold a fair series of all the British Butterflies, or all the Heteroptera and Homoptera. Three or four would take all the moths, (Macros,) and the Beetles might be got into from four to six, according to "series." As one is filled another can be placed beside it. Four or more would stand one above the other, or in pairs, according to space in room; and, if made of well-seasoned wood, would prove as serviceable as those of far greater cost and pretension.

I have had one of these little cabinets made, and have the maker's estimate for cost. Mr. S. H. Smith, of 27, Chapman Road, Small Heath, will make any number of them at the rate of 2s. per drawer, including carcase; or, if glazed, corked, and papered, ready for use, at 3s. 6d. per drawer.

LIST OF DESMIDIEÆ FOUND IN SUTTON PARK, WARWICKSHIRE.

[*Read before the Society May 18th, 1880.*]

[*The Species given in italics have not hitherto been recorded in England.*]

Hyalotheca dissiliens.
,, mucosa.
Didymoprium Borreri.
,, Grevillei.
Desmidium Swartzii.
Sphærozosma excavatum.
Micrasterias Americana.
,, ,, β.
(1) ,, *angulosa.*
,, crenata.
,, Crux-Melitensis.
,, denticulata.
,, fimbriata var.
,, Jenneri.
,, papillifera.
,, rotata.
,, truncata.
Euastrum ansatum.
,, binale.
,, Didelta.
,, elegans.
,, oblongum.
,, rostratum.
,, verrucosum.
Cosmarium bioculatum.
,, biretum.
,, Botrytis.
,, Brebissonii.
,, conspersum.
,, Cucumis.
,, ,, β.
,, Cucurbita.
,, margaritiferum.
,, pyramidatum.
(2) ,, *pseudo-pyramidatum*
,, Ralfsii.
,, tinctum.
,, undulatum.
Xanthidium armatum.
,, cristatum.
Arthrodesmus convergens.
,, Incus.
Staurastrum asperum.
,, dejectum.
,, dilatatum.
,, hirsutum.
,, margaritaceum.
,, muricatum.
,, muticum.
Staurastrum orbiculare.
,, polymorphum.
,, punctulatum.
,, sexcostatum.
,, spinosum.
,, spongiosum.
Tetmemorus Brebissonii.
,, granulatus.
,, lævis.
Penium Brebissonii.
,, closterioides.
,, Cylindrus.
,, Digitus.
,, interruptum.
,, Jenneri.
,, margaritaceum.
(3) ,, *Nägelii.*
(4) ,, *Navicula.*
Docidium clavatum.
,, Ehrenbergii.
,, nodulosum.
,, truncatum.
,, ,, var.
Closterium acerosum.
,, acutum.
,, attenuatum.
,, Cornu.
,, costatum.
,, Dianæ.
,, didymotocum.
,, ,, var. [Baileyanum.
(5) ,, *directum.*
,, intermedium.
,, juncidum.
,, Leibleinii.
,, lineatum.
,, Lunula.
(6) ,, *Pritchardianum.*
,, rostratum.
,, setaceum.
,, striolatum.
Spirotænia condensata.
,, obscura.
Pediastrum Boryanum.
,, Tetras.
Scenedesmus obliquus.
,, obtusus.
,, quadricauda.

September, 1880. A. W. WILLS.

(1.)—Micrasterias angulosa Hantsch in Rabh. Alg. Eur., No. 1,407. Archer, Mic. Journ., 1876, (Ireland.)

POND LIFE: WHERE TO FIND ANURÆA LONGISPINA.

BY J. LEVICK.

Read before the Society June 15th, 1880.

Enquiries for good localities for fresh-water microscopic life are so often made that it is very gratifying to be able to indicate a source from which an abundant supply of new and beautiful forms is now to be obtained, especially as it has none of the ordinary drawbacks common to pond hunting, which prove so insuperable to all but the most enthusiastic. The habitat referred to is not in private grounds, guarded by high and strong fences, where ominous sign-boards disclose the presence of man-traps, spring guns, &c., with other pains and penalties, thoughtfully provided for trespassers; nor is it an out-of-the-way nook, which needs a journey by rail, or a long walk, and a scramble through bog and briar to be reached. On the contrary, it is in the most convenient of all localities, a spot which may be reached at any time, without fear of injury to the daintiest of prettily-worked slippers—at home!—in the very water brought to us in pipes, and which we are using and drinking every day. This important commodity, supplied by the Corporation of Birmingham, is now a splendid source of, not only old and familiar forms of life, but even rarities, and all that needs to be done to obtain these is to turn on the tap and pass a little water through a very fine strainer or filter, taking care of the residuum, which may in this way be collected.

Under the microscope, this residuum will be found to yield a host of treasures. First to be noticed is that lovely long-spined rotifer, discovered only last year, *Anuræa longispina*, (see "Midland Naturalist," Vol. II., p. 241,) some dead, but many living, sailing to and fro, as it is wont to do, having for its companions *A. stipitata* and *Triarthra longiseta*, the latter looking like a little fat fellow on three long delicate stilts. There are also occasional specimens of *Salpina redunca*, *Dinocharis pocillum*, and a long list of other species, together with a few *Tardigrada*. A remarkable fact is that the *Anuræa longispina* are much more hardy than they were last year, whether they have become more acclimatised, or whether the water suits them better, is not apparent, but they certainly live longer after being gathered than hitherto, and do not seem at all discomforted by being bottled for a time.

Of other interesting forms, the latest addition to fresh-water life is *Ceratium longicorne*, very plentiful, but few living, though its congener, *Peridinium tabulatum*, seems none the worse for its temporary sojourn in the pipes. Large quantities of that curious compound flagellate organism, *Dinobryon sertularia*, comparable to animated ears of barley, are also to be noted. The Vorticellidæ and Entomostraca are also represented, the former by both branched or tree-like, and simple forms, and the latter principally by that lively little crustacean, with his two long and curved antennæ, *Bosmina longirostris*, evidently much the worse for his compulsory visit to town, either the distance travelled or the mode of transit being unsuited to his well-being.

Diatoms are mostly present in the pretty stellate species, *Asterionella formosa*, with a few specimens of *Synedra* and *Pleurosigma*, while desmids are fairly plentiful in the beautiful forms of *Pediastrum granulatum* and *Hyalotheca*; *Pandorina morum*, *Clathrocystis*, and other algæ have also been found.

It may not be out of place to remark that a recent visit to Olton reservoir yielded most of the good finds of last year, not omitting *Leptodora hyalina* and *Hyalodaphnia Kahlbergensis*, the former translucent beauty being scarce, but the latter abundant, with other rare entomostraca, and that at the "Roll Call" the only missing friends were *Anuræa longispina* and *Ceratium longicorne*, a gap well filled up from an unexpected source.

Possibly some who take great interest in the purity of the water supply of Birmingham may feel alarmed by this somewhat formidable list of "dreadful sounding" names of the living organisms it contains, but perhaps it may help to comfort them to suggest that the presence of these organisms should rather be taken as indicative of the general good quality of the water than otherwise, as some of them, at least, are at home and abroad known as the inhabitants of deep, clean water only.

SPONGES.*

BY H. J. CARTER, F.R.S., &c.

From the age of Alexander the Great, viz., in the fourth century B.C., when, according to Aristotle, sponge (σπόγγος) was "placed beneath helmets and thigh-pieces for the sake of deadening the sound of blows," (? the effect of blows,) almost down to the present time, the Officinal Sponge has been considered chiefly in respect to its uses; and even now a sponge to many is but a sponge in this sense, "and nothing more."

In these days of objective enquiry, however, the human mind, for the most part, is not so stolid; but, seeking eagerly, like a mariner for the relation of surrounding objects that he might be the better able to find his own position on the chart, becomes curious, among other things, not only to consider the various uses to which the Officinal Sponge may be applied, but to know what it is, whence it comes, and what position it holds in the great mass of living beings that is spread over the surface of our earth.

As we view the Officinal Sponge, it is nothing but a resilient, horny tissue, which admirably serves the purposes to which it is generally applied, and, looking at it apart from all other connections, we might be inclined to think that it is a product of the earth specially intended for the use of man and nothing else; but knowing now that there are no "hard and fast lines" in creation, wherein all things are united by gradationary transition, so as to produce universal harmony and one great whole, we are irresistibly attracted by this view to consider the connections of the Officinal Sponge, and when we find that it is actually the skeleton or organ of support of a once living being, whose varieties are spread over the earth almost as plentifully as plants, we not only become equally desirous of knowing what these are, but of interpreting thereby the real nature and position of the typical sponge through its varietal transition into the other and better known spheres of development of the animal kingdom which surround it.

Having stated that the Officinal Sponge is an animal product, it will be my business presently to prove this, merely premising now that although very low in *our* scale of creation, it is a long way on the animal side of the imaginary line of demarcation which separates the animal from the vegetable kingdoms, so that it is absolutely an animal as much as that which produces the coral.

A sponge, then, may be defined to be a congeries of living beings which, like the coral, produces various kinds of structure in accordance with the species; of which the Officinal Sponge is one that comes into the market for sale also like the coral, viz., devoid of the soft or more

*Communicated by Mr. W. R. Hughes, F.L.S., to the general meeting of the Society, held Tuesday, 29th June, 1880. On Mr. Carter's behalf, Mr. Hughes also exhibited typical specimens illustrating the eight orders of *Spongida* mentioned in Mr. Carter's paper.

animal parts which produce it. But as all kinds of sponges do not produce an almost imperishable skeletal structure like that of the Officinal Sponge it is desirable to state that (using the term "Spongida" for the whole class) it may be divided into eight orders, as follows:—

Ord. I., Carnosa.—These sponges have *no* imperishable skeleton or organ of support, and substantially present to the unassisted eye nothing but a gelatinous or semi-cartilaginous mass, charged or not with spicules according to the family to which they belong.

Ord. II., Ceratina.—In these there *is* a comparatively imperishable skeleton, composed of horny fibre cored throughout by an axial canal, which, in the fresh state, is filled with a soft granular substance that, on drying, is replaced by a hollow cavity.

Ord. III., Psammonemata.—Here there is not only a horny, fibrous skeleton, with a more or less granular axis in the fibre, but this for the most part is filled with *foreign* material, such as particles of sand, fragments of sponge-spicules, and the like minute bodies, drawn in from the exterior, and, therefore, arranged in position by the sponge *previous* to its becoming the axis of the horny filament.

Ord. IV., Rhaphidonemata.—In these, the horny, fibrous skeleton is well developed and very resilient, but the fibre is axiated by spicules, (siliceous bodies of different kinds varying in form with the species,) *produced by the sponge itself*, and therefore *not foreign;* hence might be termed "proper."

Ord. V., Echinonemata.—Here we have only to add to the foregoing an external set of *proper* spicules, which project vertically from the surface of the fibre, like prickles on a hedgehog's back.

Ord. VI., Holorhaphidota.—We lose the *horny* element here, and, for the most part, the fibre is made up of *proper* spicules, held together by the slightest quantity of sarcode; or they may be dispersed throughout an areolated sarcode, which, in the dried state, looks like crum of bread.

Ord. VII., Hexactinellida.—Again we have fibre here without the horny element, but the fibre is vitreous, so that it is like spun-glass, while all the spicules, of whatever form they may be, axiate its interior. The spicules, too, are all developed upon a hexradiate type, (hence the name of the order,) that is, the central point of the canal, (which traverses all siliceous spicules, and upon whose extension in different directions their ultimate forms respectively depend,) presents six buds or lines radiating from each other at equal angles, so that, if surrounded by a glass cube, they would meet the centre of each side respectively; or there may be no fibre at all, and the areolated sarcode when dry, like "crum of bread," as in many of the Holorhaphidota, where the spicules also are dispersed throughout the mass without any apparent regularity.

Ord. VIII., Calcarea.—Here all the spicules, instead of being siliceous, are, minerally, composed of carbonate of lime.

Of course these orders may be further divided into families, groups, and species, for which I must refer the reader to my "Notes Introductory to the Study and Classification of the Spongida," published in the "Annals" and "Magazine of Natural History" in 1875, (Vol. XVI., pp. 1, &c.) But it must not be assumed that there is any such classification in nature, for this is only human invention to aid the human memory.

Having now given an arrangement of the Spongida in which, beginning with the simplest form, viz., the CARNOSA, where there is *no* permanent skeletal structure, we passed on to the CERATINA, &c., in which there *is* one; it may be further observed that this is also the course followed by the development of the embryo of all sponges, so that before the horny skeleton is produced, it is in the state of the CARNOSA, where it remains, if belonging to this order; while in the sponges with horny skeleton, it goes on till the latter is produced, before the development is complete.

To facilitate the comprehension of what a sponge is when minutely examined, it might be stated by way of homely simile, that, in structure, it is like a bunch of grapes which has been put into melted wax and kept there until the latter is cool: after which, being held up by the stem, the wax still filling the interstices between the grapes, it is to be pared off down to the level of the bunch and the whole put into a muslin bag which is to be tied round the *neck* of the stem.

In this condition the grapes resemble the spheres which contain the animal parts of the sponge; the wax in their interstices, the parenchyma; the holes between the fibres of the muslin, the pores or inhalent orifices; the stem and its branches, the excretory or exhalent canal system; and when there is a horny skeleton, &c., produced, as in the Officinal Sponges this is developed in the midst of the parenchyma.

Examining these parts more particularly, the individual sphere is found to be lined with or composed of monociliated, monad-like infusoria in juxta-position whose cilia wave into the hollow interior; presenting two or more openings in its wall which are respectively, in continuation with tubular canals coming from the pores on one side, and going to the excretory canal-system on the other, the former for bringing in the food and the latter for carrying off the refuse. Finally, the parenchyma serves for producing the horny skeleton, &c., (where there is one,) and the temporary location of the reproductive elements, viz., the eggs and the spermatozoa, where, after impregnation, the former become ciliated all over as they pass into the embryonal state, and thus fitted for independent existence, are discharged through the excretory canal system.

Subsequently, the embryo seeks some hard object for fixation and further development, where it remains growing upwards or horizontally, until it arrives at the form assumed by the matured species; or, if by accident or otherwise it becomes detached and free, then, by growing equally on all sides at once, it may become globular.

The Officinal Sponges, which are divided into the finer and more compact or "Turkish Sponges," which are the dearest, and the coarser and less compact or "Honeycomb Sponges," which are the cheapest, grow on the rocks throughout the Torrid and Temperate Zones under more or less modified structure, but the most marketable hitherto found come from the Levant and the neighbourhood of the Bahama Islands, in the West Indies, respectively, where they are obtained by divers, who, cutting them off, bring them to the surface in baskets; after which the soft parts are drained away in the sun and the imperishable skeleton having been finally cleansed is thus fitted for sale in the marketable parts of the world.

Sponges are so easily propagated by "cuttings," when properly treated, that this has been taken advantage of in the Adriatic for growing the Officinal species.

At present it is not determined where the Spongida should be placed in the animal scale, although, of course, very low down, but when more is known of their structure and species, those alliances will be found to which I have before alluded, and their present enigmatical position thus demonstrated.

Of the important part that the Spongida have played in the geological history of the earth there is no longer any doubt. Their remains occur abundantly from the Silurian* epoch down to the present time, and when it is remembered that a narrow dredge passing over the deep sea bed of the Atlantic for a few miles, forming a kind of path-way through this vast area like a garden walk, comes up literally crammed with the remains of siliceous sponges, it not only gives us some idea of their plentifulness in this dark and dismal abode, but accounts for the immense quantity of their *débris* in some of the Mesozoic Strata, and the influence which their Silica when set free has undoubtedly exerted minerally over the composition of these strata.

Brief as this description of the Spongida is, it has been thought desirable to premise something of the kind, before giving the following:—

List of Sponges dredged by the Birmingham Natural History and Microscopical Society, Falmouth Excursion, 1879, depth 15—50 fathoms.

N.B.—Unless otherwise mentioned, the names of all the following sponges are those under which they appear, and are illustrated in Dr. Bowerbank's "British Spongiadæ," Vol. III., 1874, as this is the work most likely to be generally possessed in England.

* In course of the discussion which followed the reading of the above paper, Mr. W. J. Harrison remarked that the sponges had even a higher known antiquity than had been assigned to them by Mr. Carter, for their fossil remains had been discovered in rocks of Cambrian age. The researches of Dr. Hicks (see "Quart. Journ. Geol. Soc.") had brought to light four species of sponges from the Menevian Beds of St. David's, in South Wales, and even from strata 1,500ft. lower (corresponding to the Longmynd rocks) he had obtained two species, which had been named *Protospongia fenestrata* and *P. major*. Hence, as the organic origin of the Laurentian *Eozoon* was still disputed, the sponges were entitled to rank among the oldest known fossils.

RHAPHIDONEMATA.

1.—*Chalina inornata* (B. S., Pl. 83., figs. 12-16, not that of p. 358.) Three specimens.

ECHINONEMATA.

2.—*Microciona plumosa*, Br. *olim*. *Hymeniacidon plumosa*, Bk. (B. S., Pl. 26, figs. 7-13.) *Obs.*—This is Johnston's *Halichondria plumosa*, and although it sometimes may appear under a laminiform growth like *Microciona*, its habit is to be massive and erect. The equianchorate flesh spicule is "angulate," (B. S., Vol. 1, Pl. 6, fig. 143.) not naviculiform as in *Microciona atrosanguinea*, Bk.; and although the red colour of both species may be alike, the spiculation generally, not only differs, but the pungent (? iodine) odour of *Halichondria plumosa* is quite sufficient to detect it even blindfolded.

HOLORHAPHIDOTA.

3.—*Halichondria panicea* (B. S., Pls. 39 and 40.) Several specimens.

4.—*Isodictya Normani* (B. S., Pl. 56, figs. 1-5.) One specimen. *Obs.*—I can see very little specific difference between this and *I. fucorum* and *I. Alderi*, illustrated in the same plate.

5.—None.

6.—*Rhaphiodesma floreum* (B. S., Pl. 37, figs. 14-19.) One specimen.

7.—*Hymeniacidon suberea* (B. S., Pl. 36, figs. 1-4.) One specimen. *Obs.*—The sponge here, as is often the case, has replaced the form of the shell with its own substance. The centrally inflated minute flesh spicule has been omitted in the illustration, in accordance with Dr. Bowerbank's description, (B. S., Vol. II., 1864, p. 202, where he states that its absence makes the difference between *H. suberea* and *H. ficus*. But it is not so, for it is equally present in both species, as Johnston's type-specimen in the British Museum testifies, and every other specimen that I have met with on the south coast of Devon, where it is very common, as apparently elsewhere, for from Esper downwards all Spongologists seem to have met with it. Esper called it *Alcyonium tuberosum* (tab. 13, figs. 1-6, ed. c., 1794.)

8.—*Hymeniacidon sanguinea* (B. S., Pl. 32, figs. 5-8.) Two specimens. *Obs.*—This is abundant on the south coast of Devon, and, with *Halichondria panicea*, the hardiest of all sponges, as they frequently grow nearly up to high water mark, and are, therefore, uncovered for some hours during the fall of the tide.

9.—*Trichostemma hemisphericum*, Sars. (Forms of Animal Life on Norwegian Coast, 1872, p. 62, Pl. 6, figs. 1-15.) *Obs.*—This is a specimen of Dr. Bowerbank's genus Polymastia, and very like his *P. robusta* both in form and yellow colour.

CALCAREA.

10.—*Grantia compressa* (B. S., Pl. 1.) Two specimens.

11.—*G. ciliata*, Fleming, 1828 (B. S., Pl. 2, figs. 1-15.) Two specimens.

12.—*G. tessellata* (B. S., figs. 21-27.) Several specimens.

13.—*Leucosolenia contorta*, Br. (B. S., Pl. 3, figs. 5-10.) Two specimens. *Obs.*—Dr. Bowerbank's illustration of the linear spicule (fig. 10) is defective. There are *two* forms quite different from each other and from Dr. Bowerbank's figure. See Hæckel's "Die Kalkschwamme," under the name of *Ascandra contorta*, "Atlas," tab. 14, fig. 6, &c.

14.—*Sycon rhaphanus*, Schmidt. (Spongien Adriat, Meeres, 1862, s. 14, tab. 1, fig. 2.) Two specimens.

OTHER ORGANISMS, &c.

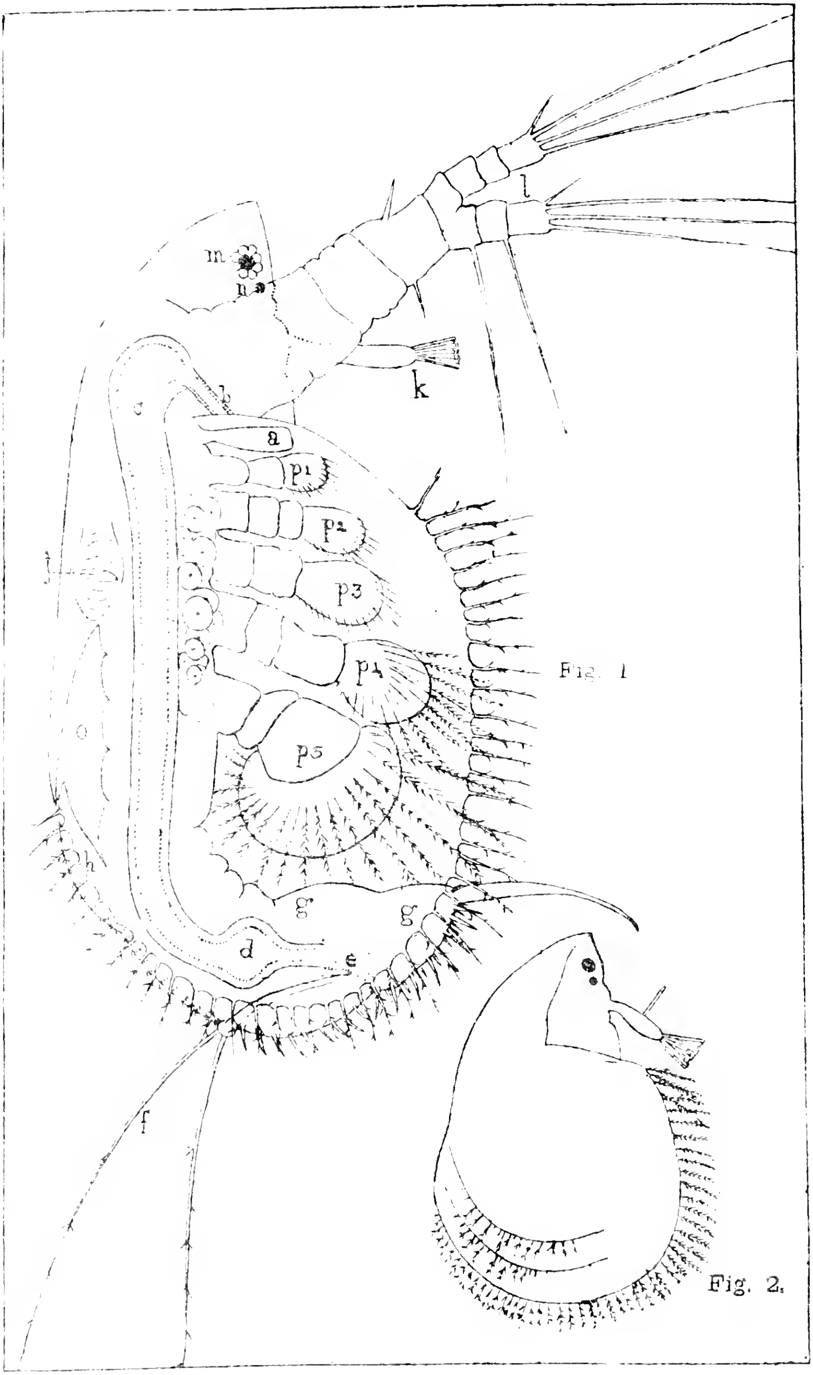
15.—*Chirodota digitata* (Echinoderm Synaptidæ) and *Compound tunicate*, gelatinous without spicules. (Synascidiæ Giard.) ? sp. *Obs.*—Examine the surface of the *Chirodota* under water with 1in. focus and high ocular to see the anchorlike calcareous spicules, which are beautiful objects under the microscope.

16.—Residue at the bottom of the jar, chiefly consisting of minute Foraminifera.

OBSERVATIONS.

The specimens of Calcispongiæ are very good, and well worth preserving. Prof. Hæckel's work entitled "Die Kalkschwamme" is essential for studying the species.

PLATE I



H. E. Forrest, del.

Ilyocryptus sordidus.

ON A RARE BRITISH ENTOMOSTRACON, *ILYOCRYPTUS SORDIDUS.*

BY H. E. FORREST, F.R.M.S.

Read before the Society November 30th, 1880.

Ilyocryptus sordidus has been found in Russia, Norway, Denmark, and Bohemia; at Dantzig, Vienna, and at Sedgefield in the county of Durham. It was found in the last-named place in 1863, and described and figured in the "Annals and Magazine of Natural History, 1863," p. 415, by the Rev. A. M. Norman.*

On the 22nd November, 1879, Mr. Bolton showed me an Entomostracon which at the time was unknown to me, but which I have since ascertained to be *Ilyocryptus sordidus*. I have to acknowledge with thanks the kind assistance of Professor A. Weismann in determining the species.

There are three known species of the genus, of which a full account has been published by W. Kurz in "Zeitschrift für wissenschaftliche Zoologie," supplement to Band xxx., 1878.

Upon referring to this work and comparing the three species there described with my specimen, I found that although there were some few points (to be noted hereafter) in which it differed from the description, there could be no doubt that it was *I. sordidus*. Mr. Bolton believes that my specimen came from a small pond in Sutton Park, near Birmingham, and that there were several more in the same water, but when I called upon him next morning there was *not one* to be seen. I had fortunately made a careful drawing of it on the previous evening, and also taken copious notes of its anatomy and peculiarities. Although I have carefully searched the pond from which it is supposed to have come, I have never found any more, and the only other specimen that I have seen is one that was accidentally preserved by another gentleman when mounting a slide of *Volvox globator* from the same locality.

References to Plate I.

Fig. 1. Female.
- *a* Mandible
- *b* Œsophagus
- *c* Stomach
- *d* Rectal-bladder
- *e* Rectum
- *f* Post-abdominal bristles
- *g* Post-abdomen
- *h* Abdominal hook
- *j* Heart or dorsal vessel
- *k* Antennules
- *l* Antennæ
- *m* Compound eye
- *n* Simple eye
- *o* Space in which eggs are carried
- *p* 1—5 Branchial limbs

Fig. 2. Male, after Kurz.

* Sedgefield, county Durham, is the only published British locality, but since writing this paper I have been favoured by Professor G. S. Brady with a list of four other places in which he has found it, and which he has kindly allowed me to publish. They are Lough Arddery, Connemara; Lough Aubwee, Connemara; pools by the side of Ennerdale Lake; and East Belsay Lake, Northumberland, (now drained.)

It is very remarkable that my own experience of the numerical scarcity of this species has been similar to that of all previous observers except Kurz. Thus Fischer says he could find only one; Leydig also found only one; Norman found three, and subsequently one more; and in the present case only two were found. This scarcity of numbers is perhaps more apparent than real, as the animal is evidently a mud-lover, and we have all searched for it in the water instead of on the surface of the mud. Kurz, the only one who found it in any quantities, obtained it free from mud by the following ingenious contrivance:—A small net fastened in the ordinary way to a metal ring, and fixed to the end of a long string by several strands, has attached to its lower edge a large stone, and to its upper edge a piece of cork. This is flung into the water as far as the string allows and sinks to the bottom, where it stands on its edge owing to the stone and cork attached to it. As it is dragged along the stone stirs up the mud in front of it, and all the lighter particles, including entomostraca and most living organisms are swilled into the net. In this way Kurz succeeded in capturing many females of the species and a few males, the only ones ever captured. This need excite no surprise, as even in the commonest Daphniadæ males are always very rare.

The following is a description of my specimen, which is a young female, drawn on Plate I., Fig. 1:—

The shape of the valves of the carapace is oval, and they are very convex, so that the thickness of the body when viewed edgeways is so great as to make it appear almost spheroidal. Their surface is reticulated all over with polygonal, mostly hexagonal markings, which are not shown in the figure. Length from top of head to bottom of carapace 1-80″, breadth 1-100″. Colour brick red. The head is bounded by a gentle curve behind, abruptly truncate in front. There are two eyes, one compound (*m*) near the apex of the head, and one smaller simple eye (*n*) below it. The antennules (*k*) are tolerably large, and spring from the forehead just below the small eye. The antennæ (*l*) are very large and fleshy and divided into two branches, the upper one four-jointed, with three long setæ and a short spine on the terminal joint; the lower one three-jointed, the first two joints each with one seta, the terminal joint like that of the other branch. *None of these setæ are plumose.* The base of each antenna also bears two spines. Perhaps the most marked feature of the animal is the bristles with which the edges of the carapace valves are fringed. These are set in an unbroken row from just below the mandibles to the junction of the valves behind. They are flexible, rather stiff, and branched *but not plumose*, varying in length from about 1-500″ along the front of the body to about half that size along the posterior edge. The abdomen bears as usual one pair of mandibles, (*a*,) five pairs of branchial limbs, (*p*. 1—5,) and a very large post-abdomen (*g*) terminating in two long rather straight hooks. This part of the body is larger than in any other species of the family with which I am acquainted, and is capable of a very wide range of motion, at times being extended quite outside the valves of the carapace, backwards, at other times thrust upwards within the carapace till the end touches the antennules.

Along the lower edge of the post-abdomen are four rows of curved spines, two on each side of the median line, the inner rows being rather smaller than the outer. All the rows converge posteriorly and meet at the point where the two post-abdominal setæ (*f*) are situated. These last are excessively long, almost equalling the body in length, and are sparsely plumose along the distal half of their length. Posteriorly the post-abdomen is provided with a rather blunt spine, (*h*,) which serves to keep the eggs in the open space, (*o*,) where they are carried by the female until hatched. I could not make out this spine very distinctly.

The branchial legs, (Plate I., *p*. 1—5,) ten in number, are largely developed, the two lower pairs at least being expanded into great fan-like paddles. Their surface is still further increased by very long delicately-plumose setæ, which spring, apparently, from the fold of integument between the two terminal joints, and extend far beyond the edge of the paddle, often projecting as far as the ends of the setæ which fringe the carapace. Indeed, the ends of these two sets of setæ are so mixed up as to make it rather difficult to determine which are which. The intestinal canal presents no peculiarities, being almost straight. There were no ova in my specimen, and from this, its small size, and relative transparency, I concluded that it was immature.

Upon comparing the above description and figure (which were compiled from notes made while the animal was alive) with those given by Norman and Kurz, it will be seen at once that my specimen differs in two points from the "orthodox" *Ilyocryptus sordidus*; but I do not feel justified in founding a new species on grounds which, although they might fairly entitle it to rank as a variety, are only matters of detail, and require confirmation, such as can be obtained only by the examination of numerous specimens.

In the typical species, the setæ which fringe the carapace are plumose along the front or ventral edge, but along the lower or posterior edge are branched, or, as Kurz expresses it, "one-sidedly feathered," (see Fig. 2,) but in mine they are of the same character all round the carapace, (Fig. 1.) Again, in the typical species, several of the setæ of the antennæ are plumose, but in mine they are all bare bristles. These setæ, too, in mine are far longer than in the figures given by Norman and Kurz. In Fig. 1 they are cut short by the "inexorable limits of space." They should be continued in imagination about another inch, and the same remark applies to the post-abdominal setæ, (*f*.)

With regard to the first point of difference, I would suggest the possibility, from the confusion which exists among them, of the setæ belonging to the branchial feet, which *are* plumose, having been mistaken for the setæ of the carapace, which in my specimens are *not* plumose but branched.

Kurz gives the measurement of the adult as:—Female, length 1-36in., height 1-46in., breadth 1-34in.; male, length 1-61in., height 1-84in. Rather more than double the size of my specimen.

The male (Plate I. Fig. 2, after Kurz) has the head larger in proportion to the carapace than the female, and has a long bristle springing from the front surface of the antennule. Its shape is not so spheroidal as the female, for at the back, *i.e.*, along the junction of the valves, the carapace is flattened, almost concave. This, I opine, is because the male has no need for an incubating chamber, since it has no eggs to carry, and the space which in the female is provided for that purpose is, in the male, reduced to a minimum. The male was found by Kurz in August.

The name *Ilyocryptus* is derived from ἰλὺς, mud, and κρυπτὸς, hidden; *sordidus* means dirty. These epithets, though by no means complimentary, are decidedly applicable to this species, for it is an inveterate mud-lover, and is usually so covered with dirt, that it is difficult to make out its internal structure; so much so indeed that Kurz gave up in despair the attempt to delineate its branchial feet, and omits them altogether from his figures; whilst in the drawing given by Norman they are represented by a few scratches of the pen. Owing to mine being a very young and relatively transparent specimen I was more fortunate in this respect, though I could only see the fifth and fourth pairs distinctly, and must confess that the three upper pairs are drawn as I *think* they are rather than as I saw them.

The motions of *I. sordidus* in the water are very curious. It keeps up a succession of strokes with its antennæ, which, however, only raise it a short distance, and the weight of its body draws it down between each stroke exactly as far as the previous stroke raised it. So the animal is condemned to spend its whole life in a very limited area, and can never reach the surface of the water.

Is not this, perhaps, the reason why the branchial feet are so large? Their great surface must be capable of producing a very strong current between the valves; and it seems probable that in order to secure an equal amount of oxygenation to the blood, a slow moving species must have a more rapid branchial current than a more locomotive one. Therefore *Ilyocryptus sordidus* should have proportionately larger branchial feet than, say, *Daphnia pulex*. Which is the fact.

The mere mud-loving propensities of the animal are not sufficient to account for its dirty clothes. There must be something which causes the dirt to adhere. According to Norman "it is probably in consequence of these sluggish habits, and of the animal rolling itself in the mud, as well as owing to the pilose covering of the shell, that it owes the coating of mud, Diatoms," &c. The existence of the "pilose covering," of which he here speaks, is rather doubtful. On this point Kurz makes a statement which is more extraordinary than anything yet related of it, and which distinguishes it from all its fellows.

As is well-known, the Entomostraca, in common with other Crustacea, undergo periodical moultings of the outer skin, and at each moult are always rather larger than the skin which they have cast off. *Ilyocryptus sordidus*, however, does not cast off the old skin of its carapace, but wears it like an overcoat that is rather too small for it outside the new one. When it has several of these old coats on, each a little smaller than the next, it presents a "ridged" appearance like an oyster-shell. But as the edge of the carapace is fringed with branched setæ, and these persist, each ridge is also bristling, (Fig. 2.) and it is this structure that causes the dirt to adhere in such quantities.

OBSERVATIONS ON THE RECORD OF PHENOLOGICAL PHENOMENA.

[*Read before the Society December 14th, 1880.*]

There are many who have shewn themselves, by their observations during the past year, willing to devote some portion of their time to the accumulation of accurate data concerning the time of occurrence of natural phenomena, and it seems to be desirable that their energies should be directed into the channel in which they will be capable of utilisation. Now before any such record as those to which we refer can be of real scientific value, certain conditions must be fulfilled, which, we are sorry to say, are not sufficiently regarded by some members of our volunteer staff of observers; and it is in the hope that they may themselves perceive this necessity that these remarks are penned.

Firstly, it is absolutely essential that the species to which the observation refers should be unmistakable; without this it is so much labour thrown away. The scientific name must be given accurately, and, in doubtful cases, with the "authority" appended. The observer may know in what sense he himself uses the English name, but he will be a bold man if he assumes that all others use it in the same sense as he does. The possibility of misidentification sometimes exists, indeed, even with the scientific name, but it is immensely increased by the misplaced use of the "popular" name in cases like these, where there is, perhaps, no clue to what is meant except the name itself.

It is probably even more important that the scientific name should be applied to the right object. This is by no means a thing to be taken for granted; it is astonishing what mistakes will be made by really good observers. The only hope of reducing these errors to a minimum lies in subjecting the specimens, where possible, to the observation of more than one pair of eyes. This is easy to do with plants, and no records of these can be trusted which are not certified by the independent corroboration of some competent botanist. Plants have been sent for record in the "Midland Naturalist" which simply cannot and do not grow in the places to which they were assigned unless they were planted there; and one who is behind the scenes could say how often *Papaver Argemone* is mistaken for *P. Rhœas*, *Malva rotundifolia* for *M. sylvestris*, *Polygala depressa* for *P. vulgaris*, and so on. In relation to the last two, for instance, the time of beginning to flower is quite distinct, and, leaving out of question the specific distinction of the plants, it is obvious that a mixed record of the times of flowering of the two varieties can convey no useful information whatever. The same remark applies to the records of all those variable plants which have in recent times been divided into numerous "species;" and observers, who are not competent to distinguish between the forms which these species assume, will be well advised if they leave them altogether alone. In fact, it is the most easily understood and most wide-spread species which are the most valuable for the purpose which we are now considering.

Scilla nutans and *Ranunculus Ficaria* are typical examples of the kind of plant to which the attention of amateur botanists should be directed, if only because they cease flowering during the later portion of the year. There are many plants, such as *Ranunculus repens* and *R. bulbosus*, which will go on flowering under certain conditions all the winter through, and it is easy for a superficial observer to mistake a straggler of last year for an early flower of the present. Again, misdirected zeal is often shewn in recording that certain species were in bloom on the first day of January. The primrose (*Primula vulgaris*) is a well-known example. But Flora does not make a clean sweep of her treasures at midnight on the 31st of December, to commence the new year with a botanical *tabula rasa*. The only interest, from our point of view, lies in ascertaining how soon in December the primrose opened its first flowers.

The same plant will serve also as a proof of the importance of a third requisite of utility in the observation, namely, the aspect and soil of the locality. In examining a limited district in early spring, we may hunt everywhere without finding a single expanded primrose, till we come to some favoured and well-sheltered wood, and there they may be in bloom by hundreds. We can ourselves cite an instance where a distance of only a dozen yards separated two spots, in one of which the primroses were in full flower, while in the other there was scarcely a single bud, and in the latter, indeed, no flower appeared till several weeks after. Those who were on the spot could give sufficient reasons for the difference, but the mere record of the date would have been quite misleading. The object of the enquiry is *not* to obtain the earliest period of flowering, but to accumulate data for determining the influence of climate and weather upon growth, as well as to study the *constitution* of plants, and the coincidences of occurrence of which many are well known already to country people.

For instance, there is the proverb relating to the connection between the leafing of the oak and ash, and the weather of the succeeding summer. It has not yet been proved, in our opinion, whether under similar circumstances the oak ever puts forth its leaves before the ash. Isolated instances may be observed, but these, it cannot be too often repeated, are of little value. Those observers who record that a certain plant was in flower, a certain tree in leaf, or a certain bird arrived, when they have seen only a single specimen, are retarding instead of advancing the cause of knowledge, unless they at the same time point out the slender materials on which they base the statement.

It will now be evident that useful work in this direction is not of such easy achievement as it is sometimes thought to be: it will be necessary that the observer should limit the number of objects to which his energies shall be devoted. It is intended to publish each month in the "Midland Naturalist" (with the permission of the

Meteorological Society) the list of plants, birds, and insects which they recommend for observation in the succeeding month, and a beginning will be made in the next number with those which may be expected to occur in Jan. and Feb. The Meteorological Society undertook some years ago the guidance and collation of phenological observations, without which they would yield no result, and, with the assistance of the Rev. T. A. Preston and others, drew up a code of Instructions,* a revised edition of which is to be issued soon. While waiting for it, those observers who cannot obtain a copy of the old edition may borrow one from Mr. Preston, as he kindly informs us in a letter. From him also may be obtained any information upon the subject, and he will gladly welcome any addition to his staff of observers, especially in the more northern districts. Blank forms for the record of observations may be obtained from the Secretary of the Meteorological Society.

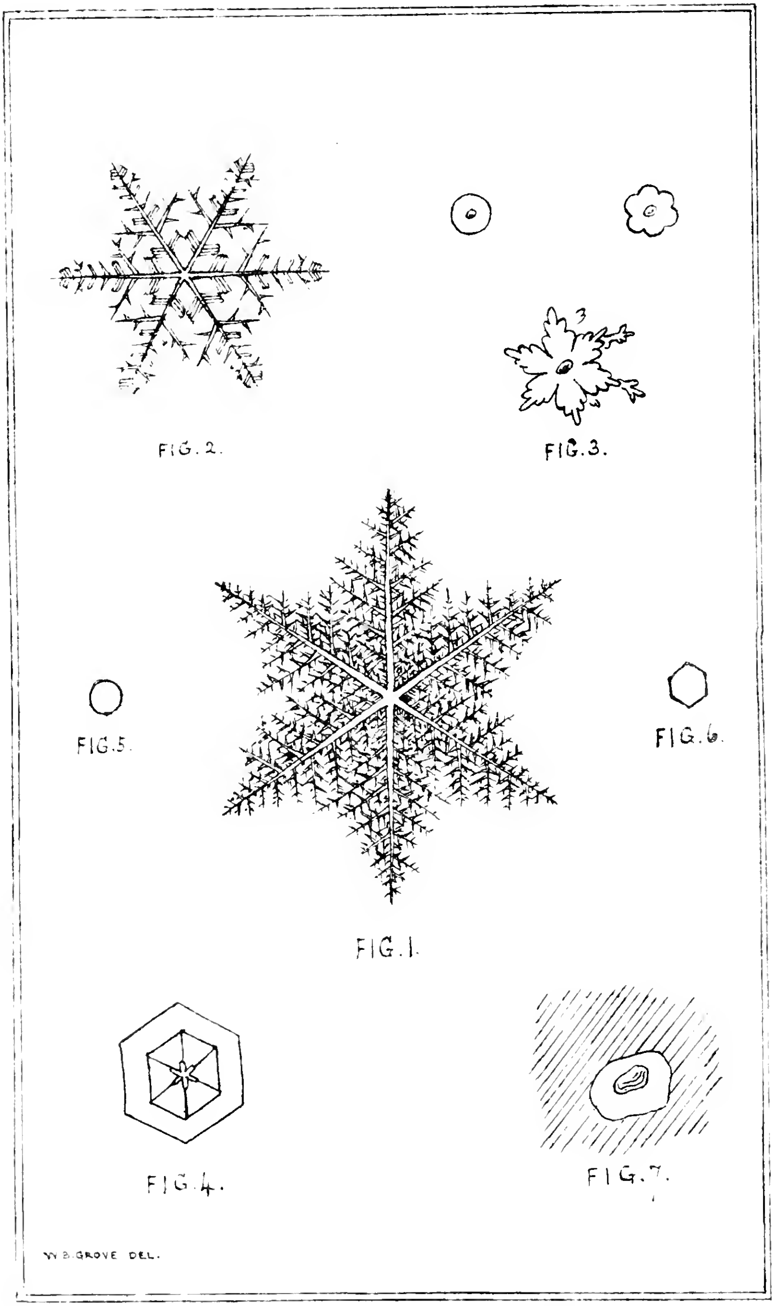
Finally, we will recapitulate the essential conditions of a good phenological botanical observation. It must embrace (1) the name of the object; (2) the date; (3) the exact locality; (4) the habitat; (5) the aspect and soil; (6) the elevation, at least in hilly districts; (7) any other circumstance, such as the *stage* of foliation or flowering, the number of specimens, &c., which may be necessary to place the reader in the same position as the observer for estimating the value of the observation.

"False facts in science," says Professor Jevons, in the "Principles of Science," "are more mischievous than false theories." The latter can be overthrown by the labours of other enquirers, the former may long remain a stumbling-block in the way of truth. There is distinct need of a higher code of morality among botanical observers. Those who study the progress of physical science are aware that for the most part the standard of accuracy exacted from those who pursue that branch of knowledge is very high, and that an investigator who has any regard for his reputation will publish no statement until he has checked it, and verified it to the utmost of his power. The history of English Botany is sullied with some passages which, if they do not show a direct intention to deceive, at least originated in the most culpable carelessness. Those who have the honour of science at heart should not be silent on such points, since by their utterances is formed that public opinion by which even the carelessness that stops short of dishonesty is compelled to take thought and amend its habits. In the race to be first to record a new species, a new locality, or an earlier date, it is sometimes forgotten that the only object of pursuit worthy of a man of science is the *truth*.

W. B. GROVE, B.A.
J. E. BAGNALL.

* "Instructions for the Observation of Phenological Phenomena," published by Williams and Strahan, 7, Lawrence Lane, Cheapside, London, 1875, price 6d. It is said to be out of print, but we recently obtained a copy from the publishers, so that probably a few remain.

Plate IV.



Crystallisation of Water.

CRYSTALLISATION OF WATER.

BY W. B. GROVE, B.A.

[*Read before the Society, under the title "Some Phenomena of Ice," March 16th, 1880.*]

The sharp frosts of last winter and the preceding afforded us unusual opportunities of becoming acquainted with many of the phenomena of ice formation. It may not be known to all the readers of the "Midland Naturalist" that an amorphous, apparently structureless, block of ice is really a crystalline body; it is indeed by no means evident at first sight that such is the case. We know that, when a thin film of water crystallises on our window panes, strange and beautiful forms appear, amidst which we can often trace somewhat of regularity and the predominance of that angle of sixty degrees to which a snow-crystal owes its well-known outline, and we might conjecture *a priori* that the crystals of which ice is composed, could we but obtain them perfect, would be seen to be formed upon the same plan.

It was Professor Tyndall, I believe, who first showed indirectly that such is the case. Everyone who has read his lectures on "The Forms of Water,' or on "Heat as a Mode of Motion," will remember the beautiful experiment by which the intimate structure of ice is revealed. A slab of ice is cut parallel to the plane of freezing, and the concentrated beam of the electric lamp is sent through it. The heat melts the ice in parts, within the block as well as on the surface, the greatest effect being confined to a depth of about one inch. Each liquefied portion in the interior begins as a minute point, which as it enlarges assumes the shape of a six-petalled flower (Plate IV., Fig. 3;) the petals, at first rounded, become gradually more and more pointed and serrated, and at last approach some of the characteristic forms of snow-crystals. These liquid flowers are evidently the cavities previously occupied by those ice-crystals, which for some reason or other have yielded soonest to the influence of the transmitted heat.

If we wish to reproduce this effect ourselves, we have only to take a piece of clear ice, form it into a slab, the plane surfaces of which are parallel to the plane of freezing, (by sawing it, or by pressing each side alternately on a hot metal plate,) and then expose one of these surfaces to the warmth of a glowing fire. Hold it as close as the hand can bear, and in an instant the previously transparent ice is clouded with multitudes of minute bubbles (or what appear to be such) and, on

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REFERENCES TO PLATE IV.

Fig. 1. Ice-crystal, formed on the surface of still water, natural size.
Fig. 2. Snow crystal, magnified.
Fig. 3. Ice-flowers, × 10.
Fig. 4. Hexagonal snow crystal, × 3.
Figs. 5 and 6. Liquid discs in ice, × 10.
Fig. 7. Composite cavity in ice, containing air and water.

removing the slab to a colder place and examining it through a lens, we shall see numbers of these ice-flowers within the slab, each with a "bubble" in the centre. Their diameter is usually about 1-10th to 1-20th of an inch, and they are only dimly visible, because the refractive indices of ice and water, at the freezing temperature, are nearly the same.

But what are these "bubbles?" Let us appeal to experiment for the answer. If we place a piece of ice containing them in warm water, we shall find that when the ice surrounding them is melted they suddenly collapse and disappear utterly. If we treat a bubble of air contained in ice in the same way, we shall see the bubble rising through the water as soon as it is liberated. Hence we infer that this apparent bubble, which occupies the centre of the ice-flower, is really a vacuum. Now observe how unexpectedly a law of nature steps in. Ice is less dense than water, as is manifested by its floating, and, when a certain quantity of ice is melted, the resultant water occupies a smaller volume: so the formation of each flower is attended with the formation of a vacuum.

This contraction of the volume of water, however, takes place in a peculiar way. When the cavity is small, and its sides close together, the molecules of water are able to bear the strain put upon them, and separate by a minute interval, so as still to fill the space. Thus the discs are at first bubbleless, but as the quantity of ice melted increases, the strain becomes greater, until at last the molecules yield to the influence of their mutual attractions, and rush together *suddenly* into a smaller space. Thus the formation of each vacuum is attended with a "clink" which is clearly audible, and resembles, on a smaller scale, the metallic clink heard when water deprived (as this ice-water is) of its dissolved air is shaken in a tube, as in Donny's well-known experiment.

The planes of these "negative" crystals, as they have been termed, lie in the planes of freezing, that is, in ordinary cases, parallel to the surface of the water. We may detect this direction in any block of lake-ice, taken at random, either by developing the flowers or by observing the bubbles which are almost invariably entangled in it. We shall see layers cloudy with bubbles, separated by layers of clear ice, the plane separating the two being, often, perfectly distinct on the lower side of the clear layer, but less so above. The explanation of this appearance is that the clear ice is that produced by slow freezing, *e.g.*, during the daytime, when the molecules of water, as they fall into their places in the crystal, have time to push out of the way the particles of air entangled among them. These collect into bubbles on the lower surface, and if, *e.g.* after sunset, a sudden fall of temperature takes place and the freezing becomes more rapid, they are unable to extricate themselves and become locked in their icy prison. It will be noticed that the bubbles, which would be normally nearly spherical, are usually pear-shaped or conical, with their longer axis vertical and the narrow end pointing downwards as if they had been gradually compressed laterally by the expansion of the surrounding water as it passed into the solid state. Larger bubbles are less frequently met with in lake-ice; these are probably filled with gases emitted from the decaying matter at the bottom, which we know is continually rising to the surface in bubbles when the water is unfrozen.

The ice made in freezing machines, or on a small scale in a test tube, is generally cloudy, being quickly formed. The reason why slowly-formed ice is transparent is that the crystals are in perfect optical contact, but it is said to be possible, by carefully exposing a block to the action of heat, to cause it by a smart blow to fall into pieces which are roughly hexagonal prisms. This, however, I have not been able to do when I tried, but I once did something like it involuntarily. The winter before last, when I was skating at the Edgbaston Reservoir, I lost my balance and fell. The ice cracked ominously, and on rising I saw the spot where I had come in contact with it marked by a large six-rayed star, the arms of which were from twelve to eighteen inches long, and arranged almost exactly at equal angles of sixty degrees, like the main rays of the crystals (Figs. 1 and 2.) I also produced the same effect last winter in a water-tub by striking the ice with a hammer, the rays being longer or shorter according to the strength of the blow. It seems probable that the ice cracked in these directions because these were the planes of least resistance, like the planes of cleavage in crystallised minerals.

It is interesting to see ice thus analysed, and its component parts demonstrated, but it is still more interesting to observe the synthetic process, by which the crystals are formed. This is in general so masked by various circumstances that they rarely assume their proper shapes, but under special conditions perfect crystals may be obtained. They have been noted by several observers, but are undoubtedly of comparatively rare occurrence. I am pleased therefore to record the fact that, one morning in December, 1879, I found floating freely on the surface of a basin of water, in my house, three thin plates of ice, the smallest but most regularly formed of which is represented in Fig. 1 of its natural size, about two inches in diameter. It will be seen how closely it imitates the form of the snow-crystal which is sketched above (Fig. 2.)

The main conditions necessary for the formation of such crystals seem to be intense cold, combined with slow freezing. Professor Tyndall, to whom I am indebted for many of these facts and explanations, observed the formation of little six-rayed stars of thin ice in the vessel of an artificial ice machine, in which the action was proceeding very slowly. He believed the observation to be then new, and it gives me, therefore, great pleasure to quote the following account of a similar occurrence described in a letter to me by Mr. W. H. Wilkinson. He says that it happened on a Christmas-day, some years ago, when the thermometer in Birmingham fell below zero :—

"In my greenhouse there was an aquarium, some 5ft. long, with about 6in. deep of water in it.

"The doors being closed, the temperature was prevented from falling below 32° during the night, but early on the morning of Christmas-day, as I entered, the cold air rushed in; and my attention was first called to the intensity of the frost by the fact that some water, accidentally spilt, was frozen solid before I had time to walk the length of the greenhouse.

"On looking into the aquarium to see how the fish stood the cold, my attention was attracted by some little stars rising from the sides and bottom, and floating up steadily to the surface of the water. They sometimes came up singly, and sometimes in clusters of two or three or more.

"They at first formed little islands of ice on the surface, by joining together at their points; others rising under them soon filled up the spaces, and formed thin sheets of fragments of ice, with rough, jagged edges.

"In a short time the entire surface was covered with ice, and in the course of a few hours the aquarium was frozen solid."

Before concluding, I must refer to two other phenomena, which anyone, who tries to reproduce the ice-flowers, will probably meet with. Sometmes, instead of liquid flowers, we get only liquid discs, that is, extremely thin layers of water, which are unattended by a "bubble." I have seen these discs hexagonal, instead of circular, (see Figs. 5 and 6.) presenting a close resemblance to the hexagonal plate snow-crystal which is frequently seen. Their average diameter is the same as that of the flowers, and they also lie in the plane of freezing. If, instead of the ice being perfectly clear, it contains bubbles of air, then, on exposure to heat, we shall find the portion of ice immediately surrounding the bubble to melt. Thus we obtain composite cavities, as drawn in Fig. 7, where the central bubble represents the air, and the clear area surrounding it the water. The cavity occupied by the water does not, in this case, generally assume the form of an ice-crystal. It is usually rounded, but sometimes slightly crimped at the edges. Since the ice in melting shrinks to a smaller volume, it follows that the air composing the bubble must now be rarefied; and this is confirmed by observing that when the ice surrounding it is melted, and the bubble set free, it invariably collapses to a much smaller size.

The question arises, why should the ice melt immediately around the bubble in preference to any other part? The answer to this question depends upon an interesting property of the particles of matter. We know that a liquid in its ordinary condition is continually giving off vapour from its surface; but why from its surface only? Simply because the molecules there have greater freedom of action, are less hampered by the surrounding molecules than those within the body. So, in a mass of ice, the particles on the surface yield to the influence of the heat sooner than those within the mass. But it is obvious that the particles in immediate contact with an enclosed bubble are, in this respect, in circumstances similar to those on the exterior of the ice. The heat of a body is at the present day attributed to a motion of the molecules composing that body. When the motion of the particles of a solid reaches a certain limit, the solid becomes a liquid; when the motion is further increased, the liquid becomes a gas. And we can easily see that a molecular motion, which is incapable of liberating the particles of a solid mass, may be propagated through them without prejudice to its solidity; yet, when this same motion reaches the particles bounding a cavity, it may suffice to liberate them. Professor Tyndall, from whom I have derived this explanation, made a number of experiments, which entirely confirm it; and those who have studied his theory of glacier motion know that the same idea has been applied to explain the effect of regelation upon which the theory is based.

There is one other point of view in which the ice-flowers teach us a lesson. Why should one portion of a solid block of ice melt sooner than another? The heat which liquefies these flowers must have passed through the surrounding ice before it reached them. We conclude, to quote Professor Tyndall's words, that "the absorption is fitful, and not continuous; and there is no reason to suppose that in other solids the case is not the same, though their constitution may not be such as to reveal it. There is no such thing as absolute homogeneity in nature. Change commences at distinct centres, instead of being uniformly distributed; and in the most apparently homogeneous substance we should discover defects, if our means of observation were fine enough."

THE

CRYPTOGAMIC FLORA OF WARWICKSHIRE.

BY JAMES E. BAGNALL.

In compiling this portion of the Warwickshire Flora I have endeavoured to bring together the various notes given from time to time on this subject, which are at present scattered through various works, so that those botanists who may feel inclined to follow up these investigations may be able easily to see what has been done already, and also to decide, with little trouble to themselves, whether the plants they find have been previously recorded, or are additions to our county flora. In compiling such lists as this the great difficulty is to settle the synonymy of the plants, many of the names of the older botanists being now obsolete, and some transferred to other and frequently very different plants from those intended by past recorders. In the Lichens and Fungi I have found it extremely difficult in many cases to decide what plant such an author as Purton meant by the name under which he recorded it. To take a single instance, Purton records from Oversley Wood a rare Lichen under the name of *Lichen digitatus;* in "The English Flora," Vol. V., page 240, this is called *Scyphophorus digitatus*, and by Leighton, in "The Lichen Flora of Great Britain," page 68, it bears the name of *Cladonia digitata*. Thus in three standard works the same plant is placed in three different genera. Nor is this a singular instance. Hence if I should omit to notice some of the plants recorded by the older botanists it will be because I have been unable to trace them to their modern name.

In the Fungi I have received great assistance from the notes of that eminent fungologist, the late Mrs. Frederick Russell, of Kenilworth, and I have to thank her niece, Miss Worsley, for having so courteously allowed me to copy the list of Fungi found by her aunt in the neighbourhood of Kenilworth, Warwick, &c.—a most extensive list, the result of many years' careful and successful study of these plants.

The Moss Flora, with one or two exceptions, is compiled entirely from my own note book, and the sign ! after the name of a locality indicates that I have myself collected and examined the plant cited from that locality. Authentic specimens which I have seen from localities given on the authority of other collectors I have indicated by the sign ! after the *name of the recorder*.

The past records of Warwickshire mosses are very scanty, the only works within my reach in which any such records are given being Purton's "Midland Flora" and Perry's "Plantæ Varvicenses Selectæ," the notes in the latter being entirely copied from the first-named work. Unfortunately Purton has not given localities for any but the rarer mosses, and has, therefore, left it uncertain whether the mosses recorded as "common," "frequent," &c., were found by him in Warwickshire or in other parts of the Midlands. I have only recorded those mosses for which he gives a Warwickshire station, although I am convinced that many that I omit were found by him in this county.

The Moss Flora of Warwickshire is by no means an extensive one, and our really rare species are few in number compared with those of such counties as Surrey, Kent, or Gloucester. Still the county has yielded a few rare species, and has the merit, if merit it be, of having added at least two new species to the British Flora. The present list is, I am convinced, an imperfect one. Much of the county has been at present neglected, and to many districts I have been able to make only flying visits. From the neighbourhood of Rugby I have no notes. The Edge Hill district has only once been visited by myself; and I know of no records from that part of the county which lies south-west of the Edge Hills; in fact, so far as I have been able to make out, very little has yet been done in the southern portion of the county, and I am convinced that much good work still remains to be done.

This list will include the Musci, Hepaticæ, Lichens, and Fungi. The Algæ I shall leave for a more competent botanist.

The following is a list of the books used in this compilation, with the abbreviations employed in these papers:—

Purt.—"A Midland Flora," 2 vols., 1817. T. Purton.

Purt.—"An Appendix to the Midland Flora," in two parts, 1821. T. Purton.

E. F.—"The English Flora," Vol. V., Part II. Rev. M. J. Berkeley, M.A., F.L.S.

MUSCI.

The classification adopted is that of "The London Catalogue of British Mosses," by C. P. Hobkirk and H. Boswell, 1877, a classification which in my opinion has the merit of being a very natural one, and which will probably be adopted by the majority of working botanists.

In the following list I have only quoted the synonyms of the "Midland Flora," and the three works on British mosses most generally in use in this country, which are indicated as under.

Wils.—Wilson—"Bryologia Britannica," 1855.

Berk.—Berkeley—"Handbook of British Mosses," 1863.

Hobk.—Hobkirk—"Synopsis of British Mosses," 1873.

SECTION I.—ACROCARPI.

SPHAGNACEÆ.

1.—*Sphagnum acutifolium* Ehrh. Marshes and bogs, local. A very varying species, both in size and habit, often tinged with a reddish tint, fruiting in Autumn. Abundant in Sutton Park! Coleshill Bog! Trickley Coppice, in drains! New Park! July, August.

Var. patulum *Schimp.* On elevated grassy places, rare, growing in smaller, looser tufts, of a pale green colour, apparently rare in fruit. Fruiting in Autumn. Sutton Park! near most of the streams. Coleshill Bog! July, August.

2.—*S. fimbriatum* Wils. In marshes and bogs, rare. Sutton Park! in marshy ground above Blackroot Pool, destroyed by railway embankment in 1876, not found there since. Marshy ground in Bentley Park, near Atherstone, 1878! July.

4.—*S. squarrosum* Pers. Boggy places, rare. Sutton Park! near Bracebridge! Blackroot! Windley! and Powell's Pools! readily known by its very squarrose leaves. July, August.

Var. b. teres *Angst.* Marshes, rare. In marsh by Windley Pool, Sutton Park! 1876.*

7.—*S. intermedium* Hoffm. *S. recurvum*, Beauv., Hobk., Berk. *S. cuspidatum*, *b. recurvum* Wils. In bogs and marshes, very variable, local, rare in fruit. Abundant in Sutton Park! but usually barren. Coleshill Bog! fruiting. Trickley Coppice, in drains! July.

8.—*S. cuspidatum* Ehrh. Near streams, rare. In a drain in Trickley Coppice!

11.—*S. subsecundum* Nees. *S. contortum*, *b. subsecundum* Wils. Turfy bogs, marshes, local. Sutton Park! Coleshill Bog! Haywoods, in first drive below Woodman's cottage! Spring Wood, near Hockley Cut-throat Coppice, near Solihull! July!

Var. b. contortum *Schultz.* S. contortum *Wils.*, *Berk.*, *Hobk.* In marshes, bogs, and watery places, local, rare in fruit. Sutton Park frequent! Coleshill Pool! Coleshill Bog! Arley Wood! Bannersly Pool! Drive by Chalcote Wood! Cut-throat Coppice, near Solihull! In fruit in a small bog, near Great Packington.

Var. b. contortum, forma rufescens, *Nees and Hsch.* occurs in small pools in bog, near Packington Park! July.

Var. c. turgidum *Mull.* S. contortum, c. obesum *Wils.*, *Hobk.* In small pools, bog near Packington Park! In bogs above Blackroot Pool, Sutton Park!

Var. d. auriculatum *Lind.* In drains and wet bogs, rare. Above Blackroot Pool! Pool Hollies Wood! near Long Moor Mill Pool in drains! Sutton Park.

13.—*S. rubellum* Wils. Elevated places in bogs, rare. On the turfy tufts formed by *Molinia cærulea* in Coleshill Bog! fruiting in July. Dr. Braithwaite puts this as a variety of S. acutifolium in his Sphagnaceæ Britannicæ Exsiccatæ, No. 36, as I think correctly. July.

16.—*S. papillosum* Lind. Var. b. confertum. In bogs and near streams, rare. Sutton Park! fruiting in bog above Blackroot Pool! near stream above Bracebridge Pool! Pool Hollies Wood! July.

17.—*S. cymbifolium* Ehrh. In bogs and marshes. S. latifolium *E. B.*, 1405. Coughton Lane; Purt. Vol. II. The most frequent Warwickshire species; rare in fruit. Sutton Park! abundant, fruiting in Pool Hollies, 1875! Poor's Wood, Honily! Brown's Wood, near Solihull! Arley Wood! Trickley Coppice! New Park, Middleton! Coleshill Bog, fruiting 1876! bog near Packington Park! in quarry near Cornels End, fruiting! Fruits, Autumn.

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* I am somewhat in doubt as to the plant I find here being the true *S. teres* Angst.)

Var. b. squarrosulum *Bry. Germ.* In bogs, rare; in several places in Sutton Park! Bentley Park, near Atherstone, 1878!

Var. c. compactum *Schultz.* On grassy hillocks near streams. This form I have only found in Sutton Park!

WEISSIACEÆ.

27.—*Systegium crispum* Hedw. *Phascum crispum* Wils., Hobk. On banks in fields, rare. In a field near Powell's Pool, Sutton Park, 1877! Fruiting, early Spring.

31.—*Gymnostomum tenue* Schrad. On sandstone rocks and walls, rare. On stone wall at Edgbaston! sandstone rocks, canal, near Rowington! sandstone embankment, Waterworks Reservoir, Aston! Fruiting Autumn.

35.—*G. microstomum* Hedw. On banks in a sandy or marly soil, local. Edgbaston (Cameron!) Olton, canal bank! Maxtoke, near the Priory! Sutton Park, on banks near Powell's Pool! 1877, Baker's Lane, near Knowle! 1879. Early Spring.

39.—*Weissia viridula* Brid. *Weissia controversa* Hedw., Wils., Hobk., Berk. Banks, common; near Knowle! Sutton Park! Acocks Green! Marston Green! &c.

Var. b. stenocarpa. Banks, local; near Knowle, Olton Canal bank. Spring.

40.—*W. mucronata* Bruch. On marly and clayey banks, rare. Olton Canal bank, March, 1868! on banks near Duke End! Spring.

42.—*W. cirrhata* Hedw. On trees, thatch, old palings, &c., frequent. Middleton Park! Olton! Solihull! Sutton Park, Maxtoke, near Priory! Arley, &c. Spring.

50.—*Dicranella crispa* Hedw. On sandstone rocks, very rare. On sandstone rocks, lane out of Sandy Lane, Milverton, April, 1877! It is probable that this species may be found abundantly in some of the districts on the Permian, as I find it plentiful on the Permian Rocks by the Hamstead Canal, Staffordshire. Fruiting, November.

54.—*D. cerviculata* Hedw. *Dicranum cerviculatum* Hedw., Wils., Hobk., Berk. On damp, turfy heaths and banks, near streams, somewhat local. Frequent in Sutton Park! Coleshill Heath!

55.—*D. varia* Hedw. *Dicranum varium* Wils., Hobk. On clay banks and heathy waysides, not common. Sutton Park! Plants Brook! Great Packington! canal bank near Knowle! Solihull! Shrewley Common! canal bank near Rowington! November.

56.—*D. rufescens* Turn. *Dicranum rufescens* Turn., Wils., Hobk. Very rare. On sandy banks, Tythall Lane, near Solihull! As I find this moss abundant on the Permian sandstone, near Hamstead, I think it probable that it may be also found in like places on the Permian rocks of Warwickshire. November.

59.—*D. heteromalla* Hedw. *Dicranum heteromallum* Hedw., Wils., Hobk., Purt. Common. Ragley Woods! Oversley Wood! Purt., Vol. II., p. 545. Sutton Park! Curdworth! Marston Green! &c. A form with very dark-green strongly cirrhate leaves occurs on damp banks, and is most frequently barren. Sandy and damp banks. November to April.

64.—*Dicranum montanum* Hedw. On the roots of oak trees, very rare. This plant was a new addition to the British moss flora when I first found it in 1870, and was abundant in Lower Nuthurst. The tree on which it grew has since been felled, and it is now only sparingly represented. Figured and described by Dr. Braithwaite, under the name of *Weissia truncicola* (De Not.,) to which species it was then referred, but afterwards decided to be *Dicranum montanum* by Dr. Lindberg. See "Journal of Botany," October, 1871, tab. 119, fig. 2. Recorded from Abbey Wood, Kent, "Journal of Botany," January, 1877, E. M. Holmes, Esq.

71.—*D. scoparium* L. Hedge banks, heaths, and woods, local. Rare in fruit. In fruit Brown's Wood, near Solihull! Tythall Lane, Solihull! School Rough, Marston Green! Oversley Wood! Poor's Wood, Honily! July, August.

72.—*D. majus* Turn. Woods, rare. Kirsley, near Coventry, in fruit, (T. Kirk!) Brown's Wood, near Solihull! Hart's Hill Hayes! July, August.

73.—*D. palustre* Brid. *D. Bonjeani*, De Not. On banks, heaths, marshy places, old thatched roofs, &c., not rare. Sutton Park! always barren. Marston Green! abundant on an old thatched roof, Redlicap Hill, near Sutton! August.

75.—*D. spadiceum* Hedw. On damp heaths, very rare. On Coleshill Heath (H. Webb!) This plant I have looked for frequently in the locality cited, but have never seen it. I have an authentic specimen collected by H. Webb from this locality.

84.—*Campylopus flexuosus* Brid. *Dicranum flexuosum* Purt. "Rocks, high moors. The specimen which I found upon some very high ground in Ragley Woods was in close tufts." (Purt., Vol. II., p. 544.) I have never seen this moss in Warwickshire, but do not think Purton would make a mistake in the species.

88.—*C. fragilis* B. and S. *C. densus, b. fragilis* Wils. *C. densus* Berk. Heath lands, local. Sutton Park, frequent on heath lands, but very rarely fruiting. September.

90.—*C. pyriformis* Brid. *C. torfaceus* B. and S., Wilson, Hobk. On damp heath lands and the sides of streams and drains in a peaty soil, local. Abundant in fruit on boggy heath land above Blackroot Pool, Sutton Park, 1875. Coleshill bog, 1876. I believe that the variety b. Mülleri also occurs in Sutton Park, but I have never been able to get perfect specimens, so as to place the matter beyond a doubt. July, August.

BRUCHIACEÆ.

92.—*Archidium phascoides* Brid. Moist heaths. Edgbaston, (Cameron!) Shores of Coleshill Pool! April, 1868 and 1871. Very rare. April.

93.—*Pleuridium nitidum* Hedw. *Phascum nitidum* Wils., Hobk. Local, but probably frequently overlooked. Moist banks, damp sandy and marly fields. Shirley! on banks near Earlswood Reservoir! field by Powell's Pool, Sutton Park! Autumn, Spring.

94.—*P. subulatum* L. *Phascum subulatum* Wils., Hobk. Banks and fields, frequent; Acocks Green Railway bank! Olton! Packwood! wood near Maxtoke Priory! fields in Tythall Lane, Solihull! Oversley Wood! Sutton Park, 1879! Spring.

95.—*P. alternifolium* B. and S. *Phascum alternifolium* Wils., Hobk. Banks and fallow ground, rare or overlooked. In fields near railway station, Marston Green! Old clay pit, near Erdington railway station on banks! Spring.

LEUCOBRYACEÆ.

96.—*Leucobryum glaucum* L. Moist heathlands and heathy bogs, local. In many parts of Sutton Park! but always barren. Coleshill bog!

POTTIACEÆ.

109.—*Sphærangium muticum* Schreb. *Phascum muticum* Wils., Hobk. Moist banks and fallow fields, local. In sandy fields Coleshill Heath! Tile House Green, near Knowle! Fields by Powell's Pool, Sutton Park! Autumn, Spring.

111.—*Phascum cuspidatum* Schreb. Moist banks and fields, common. Coleshill Heath! Solihull! Canal bank, Acocks Green! Sutton Park! &c. March.

Var. e. curvisetum *Dicks.* Fields, rare. Sparingly in a fallow field above Coleshill Pool, March, 1869!

115.—*Pottia minutula* Schwg. Marly and sandy fields, not rare. Fields near Shirley! Solihull! Acocks Green! Sheldon! Red Hill! Bearley! Hartshill! Astley! Maxtoke! Winter and Spring.

116.—*P. truncata* L. Fallow fields, banks, heathy footways, very frequent. Acocks Green! Sutton Park! Kingswood! Autumn, Spring.

117.—*P. intermedia* Turn. *Pottia truncata, b. major* Wils., Hobk. Fields and walls, not rare. Fields near Westwood Coppice, Sutton Park! Acocks Green! Exhall, on marly banks! Bearley! Shirley! Kingswood! marly banks near Henley-in-Arden! stone quarries, Hartshill! wall tops by Arley Hall! Spring. Mr. Mitten considers this to be a variety of *P. lanceolata.* "Journal of Botany," IX., 1871.

118.—[*P. Wilsoni* Hook. Banks in a sandy soil. This species has been found by Mr. E. W. Badger, jun., at Moseley, Worcestershire, on banks, and may probably be found in Warwickshire.]

123.—*P. lanceolata* Dicks. *Anacalypta lanceolata* Wils., Berk., Hobk. Marly banks, wall tops in lias soils, &c. Plentiful on banks Chesterton Wood! Tythall Lane, Solihull! Lias wall tops at Harbury! Kineton! Fenny Compton! Edge Hills! Canal bank near Bearley! growing with *P. intermedia*, at Arley Wood! March.

128.—*Didymodon rubellus* B. and S. Walls and banks, frequent. Shortwood Coppice! walls of Kenilworth Castle! Sutton Park! Canal bridges between Olton and Knowle! Kineton, on lias walls! Arley! Hartshill! Erdington, old clay pits! October.

132.—*D. sinuosus* Wils. *Tortula sinuosa* Hobk. Walls and tree roots, rare. On wall of bridge near Henley-in-Arden! On roots of tree stump just outside Fenny Compton! very abundant on railway bridge in road from Birdingbury to Norton, 1878! Always barren.

137.—*Ditrichum flexicaule* Schwg. *Trichostomum flexicaule* Wils., Hobk. *Leptotrichum flexicaule* Berk. On marly banks, very rare. Abundant on marly bank, at Marl Cliff, just within the county! Barren.

141.—*Trichostomum tophaceum* Brid. Walls and clay banks, local. Dam of Bracebridge Pool, Sutton Park! Erdington, in old clay pits! Canal bridge, near Olton Pool! walls near Arley Wood! Fine form on dripping banks, canal near Rowington! Fruiting in Spirng.

148.—*Tortula rigida* Schultz. On walls in lias districts, rare. Wall tops just past church, at Harbury! wall of farm, Green Lanes, near Wilmecote! Fenny Compton! Kineton! Fruit, Winter.

149.—*T. ambigua* B. and S. On walls and banks. Local in North Warwick, more frequent in South Warwick on lias soils. Walls between Nuneaton and Hartshill! near Arley Wood! Astley! Bearley! Harbury! Fenny Compton! Snowford, near bridge! &c. Fruit, Winter.

150.—*T. aloides* Koch. On clay banks and mud-capped walls, local. Clay banks, Bearley! Red Hill, near Alcester! near Stratford-on-Avon! walls near Nuneaton, with last species! Canal bank, near Olton! Marston Green! &c. Winter.

151.—*T. cavifolia* Schpr. *Pottia cavifolia b. gracilis* Wils. Local. Abundant on walls capped with lias mud. Fenny Compton! Harbury! March.

153.—*T. atro-virens* Sm. *Desmatodon nervosus* Br. and Sch., Wils. *Trichostomum convolutum* Brid., Berk. On marly banks in lias soils. On a marly bank on the Alcester Road, three miles from Stratford-on-Avon, December 1875. I only found a single tuft on this occasion, and have not since been able to find more. It is a remarkable moss to find so far inland. Winter.

154.—[*T. cuneifolia* Dicks. On banks in the coal measures. This species I have found near Halesowen, near Birmingham, on the coal measures fairly abundant. It may probably be found in similar soils in Warwickshire. There is no doubt as to the Halesowen plant. It has been submitted to Dr. Braithwaite, and was also pointed out by me to Dr. Fraser and Rev. J. H. Thompson. As this is a maritime species, its occurrence so far inland is remarkable.] Fruit April.

156.—*T. marginata* B. and S. On sandstone walls and the stonework of bridges, local. Sutton Park! Walls of Rowington Hall! Walls of Meriden Park! Sandstone walls, Guy's Cliff! Allesley! Milverton! May, June.

158.—*T. muralis* L. On walls. Very common in all districts I have visited.

Var. b. incana. A very hoary form, more rare than type; growing on the mortar of brick walls, canal bridges, near Bearley! Hatton! Wilmecote! Abundant on wall at Guy's Cliff! March, April.

Var. c. æstiva *Schultz*. On damp sandstone walls. On stone coping near Powell's Pool, Sutton Park! stonework of dam, Bracebridge Pool, Sutton Park!

Var. d. rupestris *Schultz*. On old walls and marly banks, more local than type. Canal bridge, near Shrewley Common! wall of farm near Rose Hall, Alcester! near Grafton, on banks! stone walls near Fillongley!

159.—*T. unguiculata* Dill. Walls, banks, fields, &c., in most soils, very frequent and very variable. Marston Green, &c.!

Var. b. cuspidata *Schultz*. On mortar coping walls near Hartshill! on lias banks near Wixford! December.

160.—*T. fallax* Hedw. Banks in marly and sandy soils, local. Shustoke, on railway bank! Marston Green, on railway bridge! Erdington, in old clay pits! Sutton Park! November.

163.—*T. rigidula* Dicks. Wall tops; more frequently in lias districts. Wall of churchyard, Ufton, near Southam! Harbury! near Henley-in-Arden! November.

164.—*T. spadicea* Mitt. *Trichostomum rigidulum* Wils., Berk. Banks and damp walls, local. Bearley! Red Hill, on lias soil on footways! Ballards Green, by Arley Wood! bridge near Henley-in-Arden! Always barren in these districts.

165.—*T. cylindrica* Tayl. *T. insulana* De Not. *T. vinealis b. flaccida* Wils. On banks, &c., rather local. Near Claverdon, on the way for High Cross! Sutton Park. Bracebridge Pool, and Druids Well!

166.—*T. vinealis* Brid. Banks and walls, rare. Wall of Milverton churchyard !

167.—*T. Hornschuchiana* Schultz. On the mortar and walls and on the ground in marly soils, local. Canal bridge, Shirley Heath ! Bearley ! lane near Fillongley ! Yarningale Common ! Ballards Green ! Very rarely fruiting. Spring.

168.—*T. revoluta* Schwg. On the mortar of walls, not rare. Near Solihull ! Fillongley ! Shirley Heath ! Bearley ! Binton ! Sutton Park ! Shrewley Common ! All in fruit. May.

169.—*T. convoluta* Hedw. On walls and waysides, local. Sutton Park ! abundant on heathy places by Whitacre Railway Station ! wall of cottage near Meriden Shafts ! Railway bank, near Gravelly Hill ! May, June.

171.—*T. tortuosa* L. On old walls, very rare. Somewhat sparingly on a canal bridge near Olton ! I have not seen it elsewhere in the county, but have noticed it in the above station for ten years.

175.—*T. Brebissoni* Brid. *Tortula mucronata* Brid., Berk., Hobk. *Cinclidotus riparius, b. terrestris* B. and S., Wils. On roots of trees near rivers, rare. Banks of the Avon, near Bidford ! in fine fruit on banks of Alne, near Aston Cantlow ! on old bridge, near Holywell ! near Henley-in-Arden ! Fruit May.

176.—*T. subulata* L. On sandy banks, walls, and tree roots occasionally. Near Oakley Wood ! Copt Heath ! Harbury ! on walls Guy's Cliff ! Packwood ! Kingswood, Fillongley ! May, June.

177.—*T. læripila* Brid. On trees, sometimes on stone walls, not rare. Copt Heath ! Rowington ! Ufton ! Edge Hills ! Harbury ! Binton ! Oakley ! Offchurch and Birdingbury ! Milverton ! Quarries near Warwick ! May, June.

178.—*T. latifolia* B. and S. On roots of trees and woodwork near streams, rare. Wooden bridge and alders by stream near Holywell ! on willow trunks, banks of Avon, near Bidford. Bridle road from Chadshunt to Drayton Bassett ! Always barren.

179.—*T. ruralis* L. Thatched roofs, walls, &c., rare in North Warwick, frequent in South Warwick. Temple Grafton ! near Oakley Wood on trees ! wall by Chesterton Windmill ! near Hartshill ! Maxtoke Shustoke ! Coleshill ! Spring.

180.—*T. intermedia* Brid. *Tortula ruralis, b. minor* Wils. Wall tops and lias banks. Banks near Temple Grafton ! walls Edge Hills Binton ! Harborough Magna ! Fillongley ! Harbury in fruit ! May.

181.—*T. papillosa* Wils. On trees and old pales, local. Old pales Olton Canal ! foot-bridge near Holywell ! on elms near Alcester Lodge ! on ash trees Marl Cliff ! abundant on elms between Alcester and Stratford ! near Birdingbury ! Marston Green ! Always barren.

185.—*Ceratodon purpureus* L. Heaths, banks, walls, &c., very common in all the districts I have visited. May.

CALYMPERACEÆ.

189.—[*Encalypta vulgaris* Hedw. Banks. This species I have found on sandy banks near the Lickey Hills, in Worcestershire. It may probably be found on similar habitats in Warwickshire.]

192.—*E. streptocarpa* Schwg. On the mortar of old walls, rare. On a small bridge at Earlswood, near Reservoir ! on stone walls near New Fillongley Hall ! Always barren.

GRIMMIACEÆ.

194.—*Grimmia apocarpa* L. *Schistidium apocarpum* B. and S., Wils., Berk. On walls, frequent. Olton Canal bridge! Elmdon! Binton! Coleshill! Shrewley Common! Pinley!

Var. b. gracilis *N. and H.* On stone walls near Fillongley!

Var. c. rivularis *N. and H.* On stones in stream. Out of large pool at Arbury! Spring.

197.—*G. crinita* Brid. On the mortar of old walls, very rare. On an old bridge near Hatton! This interesting moss was new to our British flora when found by myself in June, 1872. It was then fairly abundant; unfortunately the next year the bridge was partly pulled down for repairs, and nearly the whole of this moss was thereby exterminated. I was pleased to notice in 1876 that it had begun to make headway again. I believe this is at present the only British station. It is ably described by Dr. Braithwaite, in "Journal of Botany," July, 1872. July.

199.—*G. pulvinata* Dill. Wall tops, very common in all the districts. Spring.

206.—*G. trichophylla* Grev. Wall tops, rare. Wall of Lapworth Churchyard! on Radford Canal bridge, near Leamington! Not found in fruit.

221.—[*Racomitrium aciculare* L. Stone walls. This species I find abundantly on walls of new red sandstone near Halesowen. It may probably be found on like habitats in this county.]

224.—*R. heterostichum* Hedw. Stone walls, rare. Pinley, near Coventry (T. Kirk)! This I also find near Halesowen. Spring.

225.—[*R. fasciculare* and *R. lanuginosum* I also find on stone walls near Halesowen. Probably both may also be found in Warwickshire.]

228.—*R. canescens* Hedw. *Trichostomum canescens* Purt. "Shores of Coleshill Pool" (Bree) (Purt., Vol. III., p. 85.) Heathy waysides, local. Near Berkswell Railway Station on main road to Kenilworth! near Four Ashes Lane leading to Monkspath! Lane from Solihull to Sharman's Cross! Always barren.

230.—*Ptychomitrium polyphyllum* Dicks. Stone walls, rare. Near Binley, Coventry (T. Kirk)! [Abundant on stone walls near Halesowen.] Fruit March.

233.—*Zygodon viridissimus* Dicks. On roots of trees, local in northern part of the county. Copt Heath! near Oakley Wood! between Stratford and Redhill! Lane to Harbury Railway Station, abundant! Bridle road from Drayton Bassett to Chadshunt! Frequent between Offchurch and Long Itchington! Bishops Tachbrook! Barren.

241.—*Ulota crispa* Hedw. *Orthotrichum crispum* Hedw., Wils., Hobk. On trees, rare. "Allesley, Bree," (Purt.) Coppice in Whew-porridge Lane, near Solihull! Shelly Coppice! June.

242.—*U. intermedia* Schpr. On trees, rare. Chalcot Wood, near Umberslade!

247.—*Orthotrichum saxatile* Brid. *O. anomalum* Hedw., Wils., Berk. Local, on stone walls. Bridge near Henley! near Wilmecote! near Holywell! Binton! Harbury! Kineton, Edge Hills! Spring.

252.—*O. obtusifolium* Schrad. On ash trees, very rare. Abundant on a small ash tree near Binton, 1876-78! I have carefully examined every other tree in this district that I could have access to without being able to find this moss again.

259.—*O. affine* Schrad. On trees, &c., frequent, more especially in South Warwickshire. Olton! Copt Heath! Rowington! Chesterton Wood! Wolstone Heath! Edge Hills! &c. June.

260.—*O. tenellum* Bruch. On trees, rare. Between Stratford and Red Hill! near Offchurch! June.

[O. stramineum *Hornsch.* Is very likely to be found on trees in the lias districts; at present I have not found it.]

262.—*O. diaphanum* Schrad. On trees, walls, and stones, frequent. Castle Bromwich! Alcester! Morton Morrell! Wolstone Heath! Sherbourn! Hampton Lucy! &c. May, June.

264.—*O. Lyelii* H. and T. On trees, ash, and elm, local. Near Solihull! Chadshunt! Copt Heath! Wormleighton! Ladbrook! Offchurch! &c. Never noticed in fruit.

265.—*O. leiocarpum* B. and S. On Ontario poplars, rare. Near Rowington Village! May.

267.—*O. rivulare* Turn. "On stones and a water wheel at Bidford Grange—Bree." (Purt., Vol. III., p. 388.)

FUNARIACEÆ.

279.—*Ephemerum serratum* Schreb. *Phascum serratum* Wils., Hobk. In fallow fields, local or overlooked. Sutton Park! Acocks Green! near Solihull! Olton! wood near Maxtoke! Coleshill Heath! March, April.

283.—*Physcomitrella patens* Hedw. Damp marly places. Damp marly bank near Fillongley Hall! Autumn.

285.—*Physcomitrium pyriforme* L. *Gymnostomum pyriforme* Purt. "Bank bounding mill pool at Oversley," (Purt.) On moist banks, &c., local. Sutton Park! Aston! Water Orton! Dukesbridge! April.

288.—*Funaria fascicularis* Dicks. *Physcomitrium fasciculare* Wils., Hobk. *Entosthodon fascicularis* Berk. Heathy waysides and fallow fields, rare. Coleshill Heath! fields near Maxtoke Priory! in a field near Ufton Church, 1872! Sutton Park! April.

290.—*F. hygrometrica* L. Walls, heathy waysides, &c., very frequent. Occurring in all the districts. May, November.

BARTRAMIACEÆ.

292.—*Amblyodon dealbatus* Dicks. On damp turfy heaths, near pools, very rare. Sutton Park! April.

299.—*Bartramia pomiformis* L. On dry shady banks, local. "Lane from Spernall Ash to Middletown" (Purt.) Sutton Park! Middleton Heath! Curdworth! Marston Green! April.

307.—*Philonotis fontana* L. *Bartramia fontana* L., Purt., Wils., Berk. Marshes, rare in fruit. "Cookhill," (Purt.) Near Windley, Keepers! and Bracebridge Pools, Sutton Park! waysides near Four Ashes, April

BRYACEÆ.

312.—*Leptobryum pyriforme* L. *Bryum aureum* E. B., Purt. Sandstone rocks and walls, local. Olton Reservoir! Rowington! Stone Quarry, Warwick! Leek Wootton! Birdingbury (Kirk)! Willenhall, near Coventry (Kirk)! Shrewley canal bank! tree pots Botanic Gardens! "Walls of Warwick Castle" (Purt.) May.

317.—*Webera nutans* Schreb. *Bryum nutans* Schreb., Wils., Hobk. Damp places, thatched roofs, &c., frequent. Sutton Park! Coleshill

Pool! Acocks Green! Yarningale Common! &c. A peculiar densely-tufted form occurs abundantly on thatched roofs by Powell's Pool, Sutton Park! May.

319.—*W. annotina* Hedw. *Bryum annotinum* Purt., Wils., Hobk. Damp sandy places, local. Rare in fruit. "Coughton Lane" (Purt.) In fruit Marston Green! Canal bank Rowington! Sutton Park! Quarries near Nuneaton! Dripping Well, Milverton! June.

321.—*W. carnea* L. *Bryum carneum* L., Wils., Hobk. Sandy and clayey banks, local. Clay pits Erdington! Canal bank Shrewley Heath. April.

322.—*W. albicans* Wahl. *Bryum Wahlenbergii* Schwg., Wils., Hobk. Marshy sandy places and damp rocks, rare Stone quarries near Nuneaton! near Corley Village! near Middleton Hall! Bearley canal bank! Binley, near Coventry (Kirk)! May.

325.—*Bryum pendulum* Hornsch. *Bryum cernuum* Wils., Hobk. Sandstone walls, rare. On the outside walls of Kenilworth Castle! walls of Bracebridge Pool, Sutton Park on walls by Rowington Church May.

326.—*B. inclinatum* Swartz. Sandstone walls and banks, rare. Railway bank near Stechford! [Abundant on walls by aqueduct, Hampstead. June.

328.—[*B. lacustre* Brid. Should be looked for in moist sandy places; it occurs in such habitats at Weolley Sand Quarries, Harborne.]

333.—*B. intermedium* W. and M. Walls, frequent. Sutton Park! Erdington! stone quarries, Warwick! Rowington Canal bank! Berkswell! June.

334.—*B. bimum* Schreb. Marshes, bogs, &c. Often abundant in the barren state. Sutton Park! bog, near Packington! Canal banks, Rowington! Olton! Holywell! &c. June.

338.—*B. erythrocarpum* Schwg. *Bryum sanguineum* Brid., Wils. *B. bicolor* Purt. "Coleshill Pool," Bree. Sandy places in quarries, &c., local. Near railway, Whitacre! Canal bank, near Kingswood. May.

339.—*B. murale* Wils. On the mortar of walls, rather local. Sutton Park! Canal bridge, near Olton Pool! Bridge, near Shrewley Heath! Ufton Churchyard wall! Baulk Lane, near Berkswell! June.

340.—*B. atropurpureum* W. and M. Walls and heathy places, not uncommon. Near Milverton Church! Whitacre Heath! Sutton Park! Ufton Churchyard wall! May.

343.—*B. cæspiticium* L. Walls, thatch, &c., common. Sutton Park! Erdington! Lea Marston! Acocks Green, &c. May.

345.—*B. argenteum* L. Banks, walls, roofs, &c., frequent. Erdington! Sutton Park! Fenny Compton! &c., &c. October.

346.—*B. capillare* L. Trees, walls, thatch, bank, common. Sutton Park! Erdington! Fillongley. May.

Var. b majus. Often very abundant on thatched roofs. Marston Green! Berkswell! &c.

A barren form often very abundant on the trunks of trees, which I cannot refer to any of Wilson's varieties.

350.—*B. pallens* Swartz. Marshy sandy places, rare. Usually barren, and abundant in this state at several pools in Sutton Park. In fruit on railway siding near the engine-house, Small Heath, 1877, locality probably destroyed now. June.

353.—*B. pseudo-triquetrum* Hedw. Marshes, rare, barren flowers found only. Sutton Park! bog, near Packington!

357.—*B. roseum* Schreb. Sandy banks, very rare, always barren. Marston Green! Sutton Park, near Bracebridge Pool, 1878!

MNIACEÆ.

362.—*Mnium affine* Bland. Shady banks, marshes, bogs, rather local. Olton Canal bank! Marston Green! Haywoods! Sutton Park! abundant in bogs above Blackroot pool, with female flowers always barren.

363.—*M. undulatum* Hedw. *Bryum ligulatum* Purt. "Marsoms Gate, Dunnington." Very rare in fruit. Shady woods and banks. Sutton Park! Marston Green! Olton! in fruit in a quarry near Allesley village! June.

364.—"*M. rostratum* Schrad. *Bryum rostratum* E. B., 1475, Purton. "Subalpine counties, rare. Oversley Hill." (Purt.) April.

365.—*M. hornum* L. *Bryum hornum* L., Purt. "Ragley woods." Banks, woods, &c., frequent. Sutton Park! near Solihull! Middleton woods! Knowle and Rowington canal bank! &c. May.

370.—*M. stellare* Hedw. Shady wet banks, local. Shustoke! near Maxtoke Priory! Dripping rocks near Milverton! always barren.

372.—*M. punctatum* Hedw. *Bryum punctatum* Purt. "Oversley Wood." Near streams, marshes, and on wet clayey banks, local, rare in fruit. Olton canal bank! Marston Green! in fruit Long Moor, Mill Pool, and above Blackroot pool, Sutton Park! March.

373.—*M. subglobosum* B. and S. Bogs and marshes, rare. Near several of the pools in Sutton Park, fruiting sparsley. Shirley Heath, in abundant fruit 1879! March.

374.—*Aulacomnion androgynum* L. Hedge banks, in a sandy soil, woods, &c., frequent, but always barren. Sutton Park, &c.

375.—*A. palustre* L. *Bryum palustre* L., Purt. "Coleshill Pool!" marshes and bogs, local. Marsh near Packington! Sutton Park frequent! Marston Green! always barren. Fruit recorded by Webb, from Sutton Park.

GEORGIACEÆ.

378.—*Tetraphis pellucida* L. Banks, woods, old tree stumps, &c. Not unfrequent with gemmiferous shoots, rare in fruit, abundant in the gemmæ state in Sutton Park! in fruit Poors Wood, Honily! near Three May Poles, Shirley! wood near Olton! New Park, 1879! August.

POLYTRICHACEÆ.

381.—*Atrichum undulatum* L. Marly banks, woods, &c., frequent. Sutton Park! Olton canal bank! Rowington! Haywoods! Ufton Wood! &c., &c. October, November.

Var. attenuatum. Sandy banks, rare. Sandy bank, Warwick Road, near Solihull!

385.—*Pogonatum nanum* Neck. Heathy footways and banks, local. Castle Bromwich! Shirley Heath! Chalcot Wood! Kenilworth Heath! abundant 1879.

Var. longisetum *Hampe.* Rare. In drive by Chalcot Wood, 1874. October, November.

386.—*Pogonatum aloides* Hedw. On marly and sandy banks, local. *Polytrichum aloides* Purt. "Ragley Woods," Sutton Park in several places! lane from Meriden to Packington Park! Shirley! Umberslade! October, November.

Var. b. minus. Sandy banks. Near Brown's Wood, Solihull! Shirley Street!

390.—*Polytrichum gracile* Menz. Woods and heath lands, local. Sutton Park abundantly! Trickley Coppice! New Park, Middleton! Brown's Wood! Hartshill Hayes! May, June.

391.—*P. formosum* Hedw. In woods and on heath lands, local. Sutton Park! Arley Wood! Wood near Maxtoke! Brown's Wood, Solihull! Trickley Coppice! New Park! Haywoods! May, June,

392.—*P. piliferum* Schreb. Heath lands and heathy waysides, local. Coleshill Heath! Old Chester Road! Sutton Park abundant! Coleshill Pool! May, June.

393.—*P. juniperinum* Hedw. Heath lands and heathy waysides, local. Plantsbrook! Sutton Park abundant! Coleshill Heath! Coleshill Pool! May, June.

395.—*P. commune* L. Marshes and bogs! local. Near Packington Park! Coleshill Bog! Coleshill Pool! Railway Cutting Acocks Green! Brown's Wood, Solihull! New Park, Middleton! Arley Wood! Haywoods! Sutton Park abundantly!

Var. c. minus *Swartz*. In drier heathy places and woods. Sutton Park! June.

SECTION II.—AMPHOCARPI.

FISSIDENTACEÆ.

399.—*Fissidens bryoides* Hedw. Marly and sandy banks, frequent. Sutton Park! Knowle! Acocks Green! &c. February.

400.—*F. exilis* Hedw. On rabbit heaps and clayey soils in woods, and on banks in Lias soils, rather rare. Bearley! Haywoods! Canal bank near Acocks Green! Lane near Yarningale Common! February.

401.—*F. incurvus* Schwg. Clayey banks, local. *F. viridulus, e. incurvus* Wils. Bearley, on banks near the village, Solihull! Canal bank near Solihull and Olton! Temple Grafton! Lane near Yarningale Common! March.

403.—*F. tamarindifolius* Brid. Marly banks, rare. Near Princethorpe! Drayton bushes! near Binton Bridges! March.

404.—*F. pusillus* Wils. Damp sandy banks, rare. Near Bacons End, Castle Bromwich! lane near Yarningale Common! March.

Var. Lylei Wils, *M.SS.* Very rare; abundant on the bank of a drain near Counden, on the way for Allesley! on Lias banks, Birdingbury Wharf! April.

405.—*F. crassipes* Wils. *F. viridulus, c. major* Wils., very rare. Sparingly by the water wheel, Guy's Cliff! April.

406.—*F. inconstans* Schpr. On Lias banks, very rare. Specimens found growing with F. incurvus near Binton Bridges are apparently identical with specimens received from H. Boswell, Esq. February.

409.—*F. adiantoides* Hedw. Marshes, rare in fruit. Sutton Park, by Windley and Long Moor Mill Pool in fruit! Ballards Green, near Arley Wood! recorded by Purton from a strawberry bed near Studley Castle. October.

410.—*F. taxifolius* L. Clay banks, somewhat local. Canal bank, Olton! Haywoods! Baddesley Clinton! Canal bank, Rowington! near Hartshill in several places! Ufton Wood, near Southam! Pool Hollies, Sutton Park! November.

SECTION III.—CLADOCARPI.

RIPARIACEÆ.

414.—*Cinclidotus fontinaloides* Hedw. *Trichostomum fontinaloides* Purt. "Mill walls, banks of rivers, rare. On a stone cistern at a watering place at Binton," (Purt, vol. ii., p. 527.) "On mill wheels at Bidford Grange, in full fruit, Bree," (Purt, vol. iii., p. 387.) The cistern at Binton I find is now altered into a modern drinking fountain. I saw no trace of the moss ; the second locality I have not yet visited.

415.—*Fontinalis antipyretica* L. Streams and pools, attached to wood, rare. In river near Holywell! in small pool near Stratford-upon-Avon Road to Alcester!

CRYPHÆACEÆ.

418.—*Hedwigia ciliata* Dicks. On sandstone, very rare. Arbury (T. Kirk)! I have seen authentic specimens collected by Mr. Kirk from this locality, but have not found it myself.

420.—*Cryphæa heteromalla* Hedw. *Neckera heteromalla* Purt. On trees, local. "In a thicket at Alcester mill, near Allesley" Purt., Bree. On elms near Stratford-upon-Avon! on elms, Wolstone Heath, near Dunchurch! near Sherbourne! Bridle Road from Drayton Bassett to Chadshunt! on ash and elm trees between Offchurch and Birdingbury! frequent in this locality. April.

SECTION IV.—PLEUROCARPI.

LEUCODONTACEÆ.

422.—*Leucodon sciuroides* L. On trees, local in North, frequent in South Warwick. Drayton bushes! Chadshunt! Chesterton! Harbury! Oakley! Exhall! Solihull! Rowington! Stratford-upon-Avon! Copt Heath! always barren.

NECKERACEÆ.

428.—*Neckera complanata* L. On trees, &c., frequent. Solihull! Shustoke! Maxtoke! Oakley Wood! &c. Not found in fruit.

429.—*Homalia trichomanoides* Schreb. *Omalia* Wils., Hobk. *Hypnum trichomanoides* Purt. "Allesley." On banks and trees, local. School Rough! Marston Green! Solihull on way for Bentley Heath! near Wroxall Abbey! November.

[*Hookeria lucens* Dill. Should be sought on moist banks in woods. Found by the late Mr. Westcott at Moseley, near Birmingham !]

LESKEACEÆ.

437.—*Leskea polycarpa* Ehrh. *Hypnum medium* Purt. "On tiles, Allesley, (Bree.") On trees, especially on the roots near water, local. Forge Mills, on alder roots! Bridle road from Drayton Bassett to Chadshunt! on poplar and alder roots, stream near Holywell! May.

440.—*Anomodon viticulosus* L. On tree roots. On ash trees, near Sherbourn! lane from Kingswood to Wroxall Abbey! Holywell!

446.—*Thuidium tamariscinum* Hedw. *Hypnum tamariscinum* Wils., Hobk. Marly banks and woods, frequent. Sutton Park! Canal bank near Rowington! Olton! &c. November.

HYPNACEÆ.

453.—*Thamnium alopecurum* L. *Isothecium* Wils. *Hypnum* Hobk., Purt. "Oversley." Banks, woods, and coppices. Rowington, in fruit! Drayton bushes, in fruit! Maxtoke Churchyard! Wootton Wawen! Yarningale! November.

454.—*Climacium dendroides* L. *Hypnum dendroides* Purt. Bogs and marshes, local. Canal bank near Holywell! Lane from Four Ashes to Box Trees, Shirley! Sutton Park! Allesley (T. Kirk)! "Cold Comfort," (Purton.)

456.—*Isothecium myurum* Poll. *Hypnum curvatum* Purt. "Allesley (Bree.") On trees, local. Plants brook! Haywoods! Holywell! Bearley Bushes! In fruit Chesterton Wood! November.

459.—*Homalothecium sericeum* L. *Leskea sericea* Hedw., Wils., Hobk. Walls, trees, thatch, &c., frequent. Sutton Park! Acocks Green! Olton! &c. November—March.

460.—*Camptothecium lutescens* Huds. *Hypnum lutescens* Huds., Wils., Hobk., Purt. "Cleve Bank opposite Salford." On banks in a marly or lias soil, local. Bearley Canal bank! near Ufton Village! Oversley Woods! not found fruiting.

462.—*Scleropodium cæspitosum* Wils. *Hypnum cæspitosum* Wils., Hobk., Berk. Tree roots near water, local. Forge Mills, near station! abundant on banks of Alne, near Aston Cantlow! borders of pool by Middleton Park! on alders near Marl Cliff! near Holywell on footbridge! near Curdworth bridge!

466.—*Brachythecium glareosum* B. and S. *Hypnum glareosum* Br., Wils., Berk., Hobk. Marly banks, local. High bank, Stratford Road, near Henley-in-Arden! marly banks near Rose Hall, Oversley! near the Bird in Hand, Henley!

468.—*B. albicans* Neck. *Hypnum albicans* Neck., Wils., Berk., Hobk. Grassy places, local. Near Upper Witton Reservoir! Sutton Park by Keeper's Pool, sparingly! Very abundant on the borders of a pine wood, Coleshill Heath!

469.—*B. velutinum* L. *Hypnum velutinum* Dill., Wils., Berk., Hobk. Banks, woods, fields, &c., common. Sutton Park! Solihull, Acocks Green! &c. November.

473.—*B. rutabulum* L. *Hypnum rutabulum* Wils., Berk., Hobk. Banks, woods, fields, &c., common. Sutton Park! Acocks Green! Solihull! &c.

A very robust form is also frequent on damp marly banks and in drains, abundant above Blackroot Pool, Sutton Park, Olton Canal bank, and other localities. November.

475.—*B. rivulare* B. and S. *Hypnum rivulare* Br., Wils., Berk., Hobk. In drains, rare. In a drain, canal bank near Holywell! November.

476.—*B. populeum* Hedw. *Hypnum populeum* Wils., Berk., Hobk. Walls, sandstone rocks, trees, rare. Tythall Lane, near Solihull! Olton Canal bank! November.

477.—*B. plumosum* Swartz. *Hypnum plumosum* Sw., Wils., Berk., Hobk. On sandstone rocks, &c., very rare. On stone coping of canal bridge, near Olton!

478.—*Eurhynchium myosuroides* L. *Isothecium myosuroides* Brid., Wils. *Hypnum myosuroides* Brid., Berk , Hobk. On trunks of trees, rocks, &c., rather local. On ash trees, near Sherbourne! Bearley Bushes, on young trees! Haywoods! Chesterton Wood! November.

482.—*E. striatum* Schreb. *Hypnum striatum* Schreb., Wils., Berk., Hobk. Woods and shady banks, local. Solihull! abundant in Drayton Bushes! Snitterfield and Bearley Bushes! Chesterton Wood in fruit! Shirley! November.

484.—*E. piliferum* Schreb. *Hypnum piliferum* Schreb, Wils., Berk., Hobk. Shady marly banks, very local. Olton Canal bank! Canal bank near tunnel under Shrewley Heath, abundant!

485.—*E. speciosum* Brid. *Hypnum speciosum* Brid., Wils., Berk., Hobk. On roots of trees near water, very rare. Coppice by Windley Pool, Sutton Park, in fine fruit, 1870! January.

487.—*E. Swartzii* Turn. *Hypnum Swartzii* Turn., Wils., Berk., Hobk. Damp banks in a marly or calcareous soil, local. Sutton Park! Coppice near New Park! Drayton Bushes! In a drain, lane from Middleton to Kingsbury! Abundant on lias bank near Kineton! November.

488.—*E. prælongum* Dill. *Hypnum prælongum* L., Wils., Hobk., Berk. Shady banks, woods, &c., frequent. Sutton Park! Acocks Green! Water Orton! &c. November.

489.—*E. pumilum* Wils. *Hypnum pumilum* Wils., Berk., Hobk. Shady and marly banks, local. Bank near Middleton! Olton Canal bank! In fruit, near Solihull, on the way for Bentley Heath, abundant! November.

490.—*E. Teesdalii* Sm. *Hypnum Teesdalii* Sm., Wils., Berk., Hobk. Very rare. "In a moist shady place, between Oversley Green and the Mill, upon the upper bank," Purton. I have not succeeded in finding this moss in the place indicated, and am unable to refer to Purton's specimen.

492.—*Rhynchostegium tenellum* Dicks. *Hypnum tenellum* Dicks., Wils., Berk., Hobk. On walls and wall tops, rare. On stone coping and brick work of the railway bridge between Sheldon and Marston Green! December.

494.—*R. confertum* Dicks. *Hypnum confertum* Sm., Wils., Berk., Hobk. Shady banks, roots of trees, woods, &c., not unfrequent. Sutton Park, in many places! Copt Heath! Solihull! road from Warwick to Stratford! Acocks Green! October.

I find a form of this species with complanate foliage on a bank in the lane from Olton station to Shirley, which I think is var. *b. serrulatum* Turn.

496.—*R. murale* Hedw. *Hypnum murale* Hedw., Wils., Hobk. On walls and bridges, local. Bridge over Canal near Acocks Green! Sutton Park, on Hartopp's Park wall! Stone wall near New Fillongley Hall! &c. November.

497.—*R. rusciforme* Weis. *Hypnum ruscifolium* Dill., Wils., Berk., Hobk. Stones near streams and water-falls, walls, damp walls, &c., frequent. Sutton Park, water-fall at Bracebridge Pool! Arbury Park! Near Holywell! Curdworth! Solihull, &c. November.

499.—*Plagiothecium latebricola* Wils. *Leskea latebricola* Wils. (Wils.) *Hypnum latebricola* Hobk. *Philoscia latebricola* Berk. On decayed stems of *Valeriana officinalis*, very rare. Windley Pool Coppice 1868! not abundant. Abundant in Waters Wood, Shustoke, 1880.

By the kindness of Dr. Braithwaite I have recently had the opportunity of comparing my plant with specimens named by Dr. Lindberg, and find my plant identical with them.

502.—*P. denticulatum* L. *Hypnum denticulatum* Dill., Wils., Berk., Hobk. In damp woods and on damp banks. Frequent. July. Sutton Park! New Park! Middleton Park. Solihull! &c.

503.—*P. elegans* Hook. *Hypnum elegans* Hook., Wils., Berk., Hobk. On dry banks in woods, very local. Sutton Park in several places! This I have also carefully compared with specimens from Dr. Lindberg.

504.—*P. sylvaticum* L. *Hypnum sylvaticum* L., Wils., Berk., Hobk. On moist banks and tree roots near water, local. Marsh above Powell's Pool. Sutton Park, in good fruit 1870! Shirley! Bearley! Hartshill Hayes! September.

505.—*P. undulatum* L. *Hypnum undulatum* Wils., Berk., Hobk. On damp banks, in woods, and heath lands, "Coleshill, Allesley, Rev. W. T. Bree," Purt., local. Sutton Park! Hartshill Hayes! Trickley Coppice! Not found in fruit.

510.—*Amblystegium serpens* L. *Hypnum serpens* L., Wils., Berk., Hobk. Banks, roots of trees, damp walls, &c., very common. Sutton Park! Olton! Acocks Green! Yarningale Common! &c. May.

511.—*A. radicale* P. Beauv. *Hypnum radicale* Wils., Berk., Hobk. On the roots of trees near water, very rare. On the roots of alders in coppice by Windley Pool, in fruit! 1876. May.

512.—*A. irriguum* Wils. *Hypnum irriguum* Hook et Wils., Wils., Berk., Hobk. On damp stone and brickwork near water, rare. Keeper's Pool, Sutton Park! April.

513.—*A. fluviatile* Swartz. *Hypnum fluviatile*, Sw. Very rare. On a water-wheel in Sutton Park! January, 1877, fairly abundant.

514.—*A. riparium* L. *Hypnum riparium* L., Wils., Berk., Hobk. On damp wood and stone work in pools, canals, &c., June, frequent. Brinklow! Canal bank, Olton! Sutton Park, Acocks Green!

Var. *longifolium* Brid. On the brickwork of a well near Sutton Park, and in Windley Pool Coppice, Sutton Park. A very peculiar form, having the habit of *Fontinalis*.

515.—*Hypnum aduncum* Hedw. *H. Kneiffii* B. and S., Wils., Berk., Hobk. Marshes and marshy meadows, rare. Sutton Park!

Recorded by Purton from Bidford Grange, (Bree,) but from his remarks it seems evident that he did not understand this species. Found by Webb in fruit, Sutton Park.

516.—*H. exannulatum* Gümb. Bogs and marshes, local. Keeper's Pool, Sutton Park! Long Moor Mill Pool! In a marsh by Blythe Bridge! Bog near Packington Park! *H. aduncum* Wils., Bry., Brit.

517.—*H. vernicosum* Lindb. *H. pellucidum* Wils. MSS. In deep marshes, rare. With fertile flowers by Windley Pool and Bracebridge Pool, Sutton Park!

518.—*H. Cossoni* Schpr. *H. intermedium* Lindb. Marshes, rare. Keeper's Pool, and other pools at Sutton Park.

I have recently had an opportunity of comparing this plant with an authentic specimen of *H. intermedium* from Dr. Lindberg, and find the two plants identical. Fruiting, May, 1878.

519.—*H. Sendtneri* Schp. Marshes, rare. Long Moor Mill Pool!

522.—*H. fluitans* L. Pools and slow streams frequent, rare in fruit. Sutton Park in many places! Marston Green! Blythe Bridge! A more rigid form than type, with sub-erect capsules, occurs on the border of the stream above Long Moor Mill Pool, Sutton Park! April—June.

523.—[*H. uncinatum* Hedw. I have a specimen of this moss, found by H. Webb at Moseley, on walls; it may possibly occur in the Lias districts of Warwickshire.]

524.—*H. filicinum* L. Marshes, drains, and damp banks in a marly soil, rare in fruit. In good fruit, Keeper's Pool, Sutton Park ! and Canal Bank, near Rowington ! Arley ! Coleshill Pool ! near Stratford-on Avon. April—May.

525.—*H. commutatum* Hedw. Marshes, and near streams, local. Near most of the pools in Sutton Park, but very rarely fruiting ! Canal bank, near Rowington ! April.

526.—*H. falcatum* Bridel. Marshes, and near streams, rare in fruit, very local. In fruit April, 1869, at Long Moor Mill Pool ! Occurring at most of the other pools in Sutton Park ! A variety, probably H. sulcatum *Schpr.*, occurs at Bracebridge Pool, Sutton Park !

535.—*H. cupressiforme* L. Trees, stones, heaths, woods, &c. Winter. A frequent and very variable species. Type frequent.

Var. minus. Sutton Park !

Var. lacunosum. *Hoffm.* Churchyard wall, Milverton !

Var. filiforme. On trees, Marston Green !

Var. elatum. Bracebridge Pool, Sutton Park !

H. resupinatum Wils. *H. cupressiforme* var., Berk. Local. On trees. Marston Green ! Sutton Park, Olton ! &c. This is a distinct variety, quite unlike type in habit. Winter.

H. Lindbergii Mitt. *H. pratense* var. *b*, Wils., Berk. Damp heathy wayside, rare. Lane, near Sharman's Cross, Shirley ! Sutton Park, by Bracebridge Pool ! Near Berkswell Railway Station. Lane from Four Ashes to Hockley !

538.—*H. molluscum* Hedw. Banks in a marly soil. Local. Sutton Park, near Long Moor Mill Pool ! Marl Cliff ! Bearley ! Near Stratford-on-Avon ! In fruit near Wixford, December, 1875 ! Near Arley !

540.—*H. palustre* L. Rare. On stone and brickwork, near water. In a drain, canal bank, near Holywell ! On brickwork of dam, Bracebridge Pool, Sutton Park ! Barren.

548.—[*H. Sommerfelti* Myr. On calcareous banks.

This moss I have found on the calcareous banks of canal near Hayhead, Staffordshire, and it will probably be found in like habitats in Warwickshire.]

550.—*H. chrysophyllum* Brid. On marly heath lands, rare. Yarningale Common, near Claverdon ! Marly banks of Rowington Canal ! Barren.

552.—*H. stellatum* Schreb. Marshes and damp marly banks. Local. Several of the marshes in Sutton Park ! Marshy heathland, Ballard's Green, near Arley Wood ! Marly bank, Wixford, on the way for Exhall ! July.

551.—*H. polygamum* B. and S. Tree roots near water, rare. Side of stream above Blackroot Pool, Sutton Park ! Marsh, near Tythall Lane, Solihull !

Var. *b*, *stagnatum* Wils. In a pond near Stratford-on-Avon, in the Alcester Road !

553.—*H. cordifolium* Hedw. Marshes and bogs, rare. Sutton Park near Bracebridge Pool ! Windley and Long Moor Mill Pool, in fine fruit ! May.

554.—*H. giganteum* Schpr. Marshes and pools, rare. Long Moor Mill Bracebridge and Keepers' Pools, Sutton Park! Marsh near railway station, Acocks Green!

556.—*H. cuspidatum* L. Marshes, bogs, and wet places, frequent. Fruiting abundantly in most of the marshes in Sutton Park! Blythe Bridge! Arbury Park! &c. April.

557.—*H. Schreberi* Ehrh. Banks, heaths, woods, local. Abundant in Sutton Park, always barren! Near Solihull! Haywoods!

558.—*H. purum* L. Heaths, woods, banks, &c., frequent, rare in fruit. In good fruit on a bank near Bentley Heath, January, 1871! Sutton Park! &c. December.

559.—*H. stramineum* Dicks. Marshes and bogs, rare. Near Long Moor Mill, Bracebridge, and Blackroot Pools, Sutton Park!

561.—[*H. scorpioides* L. Was found by H. Webb at Moseley, near Birmingham, in a marsh near where the College now stands. I have never found it in Warwickshire.]

562.—*Hylocomium splendens* Dill., Hedw. *Hypnum splendens* Hedw., Wils., Berk., Hobk. Banks and woods, Local. Banks near Blythe Bridge, Solihull! Canal banks near Olton! Rowington! Shrewley Heath! Spring Wood! and Chalcot Wood, near Hockley!

565.—*H. brevirostre* Ehrh. *Hypnum brevirostre* Ehrh., Wils., Hobk., Berk. *Hypnum triquetrum, var. b minus.* Purt. "Wood abundant. Woods, Allesley and Meriden, (Bree.)"

I have not seen this in Warwickshire.

566.—*H. squarrosum* L. *Hypnum squarrosum* L. Wils., Berk., Hobk. Woods, banks, pastures, in damp places, frequent, rare in fruit. In fruit above Blackroot Pool, Sutton Park, November, 1868! and in Arbury Park, with old capsules, near the Hall!

567.—*H. loreum* L. *Hypnum loreum* L. Wils., Hobk., Purt. "Woods nd on heaths among bushes in dry mountainous countries, common; woods, Allesley (Bree.)"

568.—*H. triquetrum* L. *Hypnum triquetrum* L. Wils., Berk., Hobk. Banks and woods in a marly soil. Local. Canal bank, near Olton! Middleton Wood! Wood near Moor Hall! Bearley Bushes! &c. November.

The following additions have been made during the present year, viz.:—

455.—*Pylaisia polyantha* Schreb. *Leskea polyantha* Wils., Hobk. On trees, rare. Frogmore Wood, Temple Balsall.

521.—*Hypnum revolvens* Swartz. In marshes, rare. Abundant at Earl's Wood, near Reservoir. May.

I have also found *Campylopus flexuosus* abundant in Sutton Park, thus confirming Purton's observation of its occurrence in Warwickshire; and *Mnium rostratum*, Shustoke, in fine fruit, April, 1880, recorded by Purton from Oversley Hill, but thought to be doubtful as a Warwickshire plant.

THE HEPATICÆ OF WARWICKSHIRE.

BY JAMES E. BAGNALL, HON. LIBRARIAN BIRMINGHAM NATURAL HISTORY AND MICROSCOPICAL SOCIETY.

The following list of the Hepaticæ of Warwickshire is the result of an examination of many districts in the county during the years 1879 and 1880, my attention during this period having been especially given to these plants. But although I have given the subject my best attention, I cannot but think that much remains still to be done; the time given to the study has been short, and the seasons have been unpropitious. Better seasons and more extended knowledge of these plants may probably lead to the finding of many plants hitherto sought in vain.

My principal text book has been that able synopsis, "Hepaticæ Europæ," by Du Mortier, and the classification adopted is that of the above work.

All the species here enumerated are represented in my herbarium from one or more of the habitats cited. Purton, in "The Midland Flora, 1817-21," gives but few localities for and records but a meagre list of these plants; these are duly quoted, in all other cases the localities given are taken from my own note book.

Unfortunately for English students, Dr. Carrington's valuable "British Hepaticæ" is still incomplete, so that the only text books available for such students are Hooker's "British Jungermanniæ," a very prizable but expensive work rarely to be met with; the 5th volume of Smith's "British Flora," in which this family is very ably treated by Sir W. Hooker; and Cooke's "British Hepaticæ." This last is a very fair synopsis, very useful, and remarkably cheap.

As the nomenclature of Du Mortier differs from that of our English authors, I have in each such case given the synonyms of both Hooker, Purton, and Cooke.

In studying this family of plants I may state that I have had the advantage of being able to compare my specimens with those contained in the "Hepaticæ Britannicæ Exsiccatæ," fasc. I. and II., by Carrington and Pearson, also with numerous specimens received from my valued correspondents, H. Boswell, Esq., E. M. Holmes, Esq., and W. Curnow, Esq., and as I have in each case been very careful in my examinations, I think my list, though short, will be found correct.

The following works are quoted by their respective abbreviations:—

Purt.—A Botanical Description of British Plants in the Midland Counties. By T. Purton, Surgeon, Alcester, Vol. II., 1817. An Appendix to The Midland Flora, Parts 1 and 2. By Thomas Purton, F.L.S., 1821.

Hook.—The English Flora, Cryptogamia, Vol. V., Part 1. By William Jackson Hooker, LL.D., 1833.

Cooke.—British Hepaticæ or Scale-Mosses, and Liverworts.

Fossombronia pusilla Dmrt. *Jungermannia pusilla* Purt., Hooker. Marly banks, woods, and fields, local. "Rare, in a cart rut, Oversley Wood" Purton. Abundant in Oversley Wood, 1879! Coleshill Heath! Bank by Olton Railway Station! Marly field, Wishaw! Field by Brown's Wood, Solihull! Oct., April.

Madotheca platyphylla Dmrt. *Jungermannia platyphylla* Hooker. On the roots of trees and in woods, local. Drayton bushes, near Stratford-on-Avon! Yarningale Common! Near the Aqueduct, Bearley! April.

Frullania dilatata Dmrt. *Jungermannia dilatata* Hook. On trees and walls, frequent. Solihull! Rowington! in fruit on Canal Bridge! Shrewley! Fruit local. April.

F. Tamarisci Dmrt. *Jungermannia tamarisci* Hook., Purt. Trunks of trees, local. "Ridgway" Purt. On elms, near Rowington Church in fruit! Yarningale Common! March.

Radula complanata Dmrt. *Jungermannia complanata* L., Hook. Trunks of trees, frequent in marly and calcareous soils. Yarningale Common! Alcester and Stratford districts! Harbury! Shustoke! Chesterton! Solihull! Fruit March, April.

Scapania undulata Dmrt. *Jungermannia undulata* L., Hook. Marsh! heath lands and waysides, local. Four Ashes, near Hockley! Salter Street, near Earlswood! Oversley Wood! Sutton Park! Marston Green! Not observed in fruit.

S. nemorosa Dmrt. *Jungermannia nemorosa* L., Hook. Marly banks in woods, rare. Oversley Wood! Lane from Four Ashes to Hockley! Sutton Park! Not seen in fruit.

S. curta Dmrt. Damp heathy places, rare. Sutton Park. My specimens from this locality have been carefully compared with Dr. Carrington's description and plate.

Plagiochila asplenioides Dmrt. *Jungermannia asplenioides* L., Hook. Moist woods and marly banks, local. Oversley Wood! Bush Wood, Lapworth! Wheyporridge and Hay Lanes, Solihull! Reddicap Hill, Sutton! Shirley! Barren.

Diplophyllum albicans Dmrt. *Jungermannia albicans* L., Hook, Cooke. Woods and marly, wet banks, local. Oversley Wood! Chesterton Wood! Haywoods! Hartshill Hayes! Trickley Coppice! Brown's Wood, Solihull! Wheyporridge Lane, Solihull! Sutton Park! Barren.

Aplozia crenulata Dmrt. *Jungermannia crenulata* Hook, Cooke. Moist heaths, rare. Holly Lane, Honily! Salter Street, near Earlswood! Shirley Heath! Fruit, March, April.

A. sphærocarpa Dmrt. *Jungermannia sphærocarpa* Hook, Cooke. Damp hedge banks and heaths, local. Sutton Park! Honily! March.

Gymnocolea inflata Dmrt. *Jungermannia inflata* Huds., Hook, Cooke. Moist heath lands and thatch, local or overlooked. On thatch of old out-house, Bodmir! Very abundant on Sutton Coldfield! Fruit, March, April.

Jungermannia ventricosa Dicks. Heath lands, rare. Sutton Park. Barren.

Lophocolea bidentata Dmrt. *Jungermannia bidentata* L., Hook. Woods, banks. Heath lands, &c., very common. Sutton Park! &c. A peculiar erect form in sandstone quarries, near Hartshill, 1880. March, April.

L. spicata Taylor. This has been recorded from near Erdington, but I have not found it in Warwickshire.

L. heterophylla Dmrt. *Jungermannia heterophylla* Sch., Hook. Moist places on decaying wood and roots of trees, very frequent. Sutton Park! Haywoods! &c.! I have found this plant in every wood I have yet visited. February, April.

Cephalozia byssacea Dmrt. *Jung. byssacea* Roth., Hook. Heathy places in a marly soil, local. Heathy footways, Mill Lane, Kenilworth! On heath lands in Sutton Park! I find a plant exactly agreeing with the specimens from Mr. Curnow, labelled *J. Starkii* in Pearson and Carrington's "Hepatic. Brit. Exsiccatæ."

C. bicuspidata Dmrt. *Jungermannia bicuspidata* L., Hook., Cooke Damp banks, moist heaths, drains and marshes, very frequent. I find this in every part of the county. Mar., Ap.

C. curvifolia Dmrt. *Jungermannia curvifolia* Dicks., Purt., Hook., Cooke. "Coleshill Heath," (Purt.) I have never been able to find this plant in the above habitat.

Blepharostoma connivens Dmrt. *Jungermannia connivens* Dicks., Purt., Hook., Cooke. "Boggy and moist shady places; not rare," (Purt.) I have never found this anywhere in the county, but from Purton's remarks I imagine he found it in his own neighbourhood.

Chiloscyphus polyanthos Dmrt. *Jungermannia polyanthos* L., Hook. Marshes and moist places, apparently local. Sutton Park abundant! marshy spinney, near Bannersly Pool! moist banks, Beardsmore, near Hockley! Barren.

Trichocolea tomentella Dmrt. *Jungermannia tomentella* Ehrh., Hook, Marshy places, very rare. Above Blackroot Pool, Sutton Park!

Cincinnulus Trichomanes Dmrt. *Jungermannia Trichomanes* Dicks., Hook., Purt. *Calypogeia Trichomanes* Cooke. Moist heaths, drains, damp banks, &c., frequent. "On a bank bounding Coughton Park." (Purt.,) Walmley! Sutton Park! fruit rare, Haywoods! April.

Alicularia scalaris Corda. *Jungermannia scalaris* Schrad., Hook. Hedge banks, heaths, and woods, frequent. Sutton Park! Trickley Coppice! Shirley! March, April.

Metzgeria furcata Dmrt. *Jungermannia furcata* L., Hook., Purt. On the trunks of trees, not unfrequent. "Cookhill and Studley." (Purt.) Yarningale Common! Shustoke! Rowington! near Solihull Hall abundant! Although abundant in the last locality, I have never found it fruiting.

Aneura multifida Dmrt. *Jungermannia multifida* Hook. Woods, dripping marly banks, &c., local. In fine fruit, Rowington Canal bank! Tile Hill Wood! and stonework of Aston Waterworks Reservoir! April.

Var. ambrosioides Nees. Damp heath lands. Holly Lane, near Honily!

A. sinuata Dmrt. *A. pinnatifida* Nees., Cook. *Jungermannia multifida b. sinuata* Hook. Damp heaths and dripping banks, local. Coleshill Heath! Stonework, Waterworks Reservoir, Aston! March, April.

A. pinguis Dmrt. *Jungermannia pinguis* L., Hook. Marshy and moist places, local. Near Iron Wood, Olbury, near Atherstone in good fruit April, 1870. Olton, near Mill Pool! Rowington Canal bank! Marsh, near Packington! April.

Purton states that this plant is common; such, however, is not my own experience.

Pellia epiphylla Corda. *Jungermannia epiphylla* Hook., Purt. Wet, shady banks, drains, bogs, &c. Very frequent, and fruiting abundantly. March, April.

Purton considered this plant rare. I find it in all the woods near Alcester, where he resided.

P. calycina Nees. *Jung. epiphylla, c. furcigera* Hook. On moist, marly banks, very local, if not rare. Abundant on Rowington Canal bank! near Bentley Park! near Shustoke! April.

Lunularia cruciata Dmrt. *L. vulgaris* Cooke. Moist banks and stone work, local. Abundant on stonework bounding Waterworks Reservoir, Aston! Sutton Park on banks of streams! Barren.

Marchantia polymorpha Lin. Moist banks and in drains, frequent. On burnt heath land, Sutton Park, abundantly in fruit! Waterworks Reservoir, Aston! Shustoke! and abundant on pots in Tropical House, Aston Lower Grounds. June, July.

Preissia hemispherica Cogn. *P. commutata* Cooke. *Marchantia hemispherica* Hook. Banks of streams, rare. Stream near Blythe bridge, Solihull! Barren when found, but fruited when grown in fern case.

Conocephalus conicus Dmrt. *Marchantia conica* L., Hook. *Fegatella conica* Corda., Cooke. Side of streams, damp banks, &c., frequent, local in fruit. In fruit Sutton Park, near Bird-in-Hand, Henley-in-Arden. March.

Anthoceros punctatus Lin. Marly and sandy fields, local or overlooked, "In a stubble field at Kinwarton." (Purt.) Field by Brown's Wood, Solihull! stubble field, near Old Park Wood, Leek Wootton. abundant! stubble field at Wishaw, abundant! October, March.

A. lævis Lin. *A. major* Purton. "Moist, shady places, rare. Arrow, August 11th, 1812." (Purt.)

Riccia glauca Lin. Marly and sandy heaths. "Rare, Kinwarton, Salford," (Purt.) Local, field by Brown's Wood, Solihull. Stubble fields at Wishaw! and Leek Wootton! abundant, Coleshill Heath! &c. Winter and spring,

R. glaucescens. Carr. Banks rare. On new railway embankment, Sutton Park. March, 1879.

Ricciella fluitans Al. Braun. *Riccia fluitans* Hook., Purt., Cooke. On the mud of pools and also floating, rare. "In a pond upon Alne Hills," Purt., Arbury Park, T. Kirk, Coleshill Pool! Barren.

BIRMINGHAM

NATURAL HISTORY AND MICROSCOPICAL SOCIETY.

TRANSACTIONS, 1881.

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AND

MICROSCOPICAL SOCIETY.

REPORT & TRANSACTIONS

FOR

THE YEAR 1881.

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TRANSACTIONS.

ADDRESS OF THE PRESIDENT,

MR. EDWARD W. BADGER,

DELIVERED AT THE ANNUAL MEETING, FEBRUARY 7TH, 1882.

When by your generous suffrages I was elected President of this Society, I did all I could to induce you to reconsider your decision and elect some one in my stead to occupy the chair, which has in former years been filled so satisfactorily by many of our worthiest members. I told you frankly that I saw before me in the then coming year such demands on my time by engagements of a private and public nature to which I was already pledged, that I felt nearly certain I should be unable to take a proper part in the work of the Society. I regret now that I did not decline the honour you did me; for the year which has elapsed since I was elected has proved even a busier one than I anticipated, and the consequence has been that I have been President in name only: the duties of the office have had to be performed by others, and chiefly by my kind friend, our senior Vice-president, Mr. Levick. To him I here publicly tender my heartiest thanks for all his valuable help, and I feel sure you will agree with me when I say that he has left nothing undone to advance the interests of the Society. For my own short-comings I offer you my sincere apologies, and I can assure you that nothing but the absolute want of time has prevented me from at least endeavouring to show how much I have had the welfare of the Society at heart.

In following the precedent of long-established usage on vacating the honourable position of President and delivering a few parting words to you, I have decided not to attempt anything in the nature of a scientific address, but with your kind indulgence shall occupy the short time at my disposal with a few general observations on the work of such societies as ours, and on some of the more obvious advantages of Natural History studies. And my main object in this will be, through you, to address what I say chiefly to the public outside these walls, in the hope of conveying to them some idea of the advantages which accrue to those who are members of this and similar societies.

Almost everyone who has had much to do with children knows how inquisitive they are: everything about them has in some degree the charm of novelty; even the most familiar objects are only known to them casually and from the outside only, and what meets their eye usually speaks to them so as to convey little more than what is very obvious. If the inquisitiveness of the child be properly dealt with, and not rashly checked, a habit of inquiry will be gradually acquired, and a power of observation will be developed which will be yearly strengthened until it becomes a valuable part of the child's nature. Some of the objects which soonest arrest a child's attention are the natural ones by which he is everywhere surrounded; and, though their simple beauties are what will at first most usually interest him, it will not be long before their less striking features will also have an interest for him too; and this is especially the case if he have wise parents or judicious teachers who know the importance of encouraging their pupils to observe and inquire. A child so happily placed, as I have supposed, will add to its knowledge daily; all it sees will at one time or other be the subject of its never-tiring investigation, and bit by bit large stores of observations will be accumulated. Now such a child living among natural objects will almost certainly grow up with an ever-increasing love of Nature, and, unless something very adverse should prevent the healthy development of his mind and body, it is not improbable that he will become a Naturalist, and will make the living objects around him, or the once living objects and the mighty forces of a former period, subjects of study; and thus he will in time become a Geologist, a Botanist, or a student of some branch of Zoology. I look for such results as these to follow as a matter of course on the extended teaching of natural science, which we may now fairly expect in schools of all grades all over the country; so that I think it not too sanguine an expectation on my part that the Natural History Societies of the future will grow in importance and usefulness, and will be more like what some of our members would gladly see them now if it were possible.

But our Societies have had to contend with the great disadvantage of the majority of their members having had no preliminary training in science; many indeed with very little training of any kind. The inborn love of living things has, however, been strong within them, and so, spite of want of knowledge or little opportunity, they have found time in adult age to follow the bent of their inclination, and the inquisitiveness of youth has come again to the surface of their lives, and they have done as men what they were not able to do as children. The boundless riches of Nature have been laid under contribution by them, her secrets have been puzzled out, and, well for them and for us, they are very willing to impart to others what they have found out for themselves. I appeal to many who hear these words whether this is not something like a rough outline of their career as Naturalists, and whether they have not won the honoured name without any set purpose at the outset, and in spite of hindrances and disappointments?

The course usually entered on by the young Naturalist is that merely of collecting birds' eggs, or butterflies, or plants, or fossils, followed in some cases by attempts to classify these collections according to their real or fancied relationships; but later on the study of structure, and of the adaptation of means to ends and environments, come to be regarded as the chief work of the Naturalist; and collecting and classifying, valuable as they certainly are, occupy only a subordinate position.

Youths with a taste for Natural History, privileged as they are in this Society to enjoy gratuitously all the advantages of membership, even while they are schoolboys, will, I should hope, have their taste for Natural Science developed in a very healthy manner, and I look forward to the Associates of to-day becoming some of our most useful members in years to come. I would urge them one and all to make full use of their privileges, and particularly to take advantage of the Friday Evening Meetings which already have proved of great use to those who have attended them. These meetings are more conversational than our ordinary meetings, and occasionally are devoted to the exhibition of manipulative processes, such as mounting specimens for the microscope, the illumination of objects under the microscope, etc., regarding which and other equally important subjects some of our more experienced members freely impart what it has cost them years of labour to obtain. Zoology, Geology, Microscopy, and Botany, each in turn is dealt with by an expert. Such arrangements as these are calculated to be of general service, and will, I trust, be long continued.

No one who has any real knowledge of any branch, or of any twig of any branch of Natural Science, will trouble to answer the ever-recurring inquiry of those who, knowing nothing of the world of wonders by which we are surrounded, and of which we ourselves are a part, and caring nothing for the mysteries and marvels of created things, ask at every turn *cui bono?* They can justify the employment of a lifetime in the study of the literature of Greece and Rome, but can have no patience with those who are striving to read and understand a chapter—or, it may be, only a page—in the everlasting Book of Life. Fortunately, the effect of Darwin's, Spencer's, and Huxley's teachings has rendered it less needful now than formerly, to enter into any justification of such studies, and the number is increasing by whom "the phenomena of nature are regarded as one continuous series of causes and effects," and who entertain the opinion that "the ultimate object of science is to trace out that series from the term that is nearest to us, to that which is at the furthest limit accessible to our means of investigation. The course of nature as it is, as it has been, and as it will be, is the object of scientific inquiry."*

*Huxley's "The Crayfish, an introduction to the Study of Zoology," p. 3.

Now surely all Societies, whether they be Royal, Linnean, or such as consist only of a few intelligent operatives in some little country town, who encourage or take part in the work of investigating the past, present, and future of the innumerable works of creation—all such Societies are aiding in the good work of opening eyes and awakening minds to what lies so near to them, but which, for so many, though equally near to them, is yet "so far away." It surely cannot now need any statement of utilitarian uses, or the setting forth of the money value of these Natural History studies, to justify their pursuit to any liberal-minded man. Societies like ours afford the means and opportunities for students in all ranks of life to meet together on a common platform, where help, encouragement, and enlightenment are ready for all those who otherwise must have remained ignorant of much that is now a source of increasing pleasure and solace to them. Natural Science studies have yielded congenial lines of investigation for hundreds and thousands of our artizans, who have also been led in the pursuit of flowers, or insects, or birds, or the minute organisms found in our pools and streams, far from the smoke of the towns, where their lives, for the most part, are spent, away into pleasant country spots, where they have communed with Nature, and got her secrets from her (for though she is coy, she is not unyielding to the persistent lover), and who, when they returned home, have found themselves invariably the healthier, and happier, and wiser for their jaunt. Nor must I omit to notice that the effect of Natural History studies, as of most others properly pursued, is to invigorate the powers of the mind, and especially to strengthen the habits of accurate observation and painstaking, which cannot be limited in their uses to these leisure-time studies, but will extend with great advantage to the daily working duties of the student in the ordinary affairs of life.

I venture to think that besides the agreeable intellectual occupation which, in our own homes, and in this room and elsewhere, our natural history studies provide for us, there is something else to be put down to their credit which must not be forgotten if we are fairly to appraise their value. I refer to the steady accumulation of facts—items of real knowledge—which the accurate observers in our Society and others of like kind are making. It is only at rare intervals that men of genius enrich us by enunciating some new law which exceptional insight and laborious work has enabled them to discover, such, for instance, as that of evolution, the greatest generalisation of modern times. But the humblest student who concentrates his efforts, and takes ordinary precautions to avoid wrong conclusions, has it in his power to definitely add to our knowledge in relation to some created thing if he will simply set the object clearly before his mind and work definitely for its attainment. These isolated facts, if sufficiently vouched for, and recorded in some enduring way, will one day have real value for other observers, and may contribute bricks for some future worker of the higher class to build with; help to confute some error, or aid some truth, or assist in the illustration of some newly-found law. Every working geologist may, by careful and repeated observations in some limited field, distinctly help his fellow-workers. So, too, may the botanist and the zoologist, whether entomology or ornithology or the lowest forms of life engage his attention.

Among the benefits which societies like ours confer must be included the giving to all who frequent our meetings the power, equal to a new sense, of perceiving the infinitely great in the infinitely little. The mass of mankind are entirely unacquainted with the marvels by which they are surrounded; they know nothing of the wonders enclosed in the limits of organisms so minute as to be visible only under the microscope, and with hundreds of which the members of natural history societies have a more or less familiar acquaintance. In this way, little by little, the student gets to know more of living things. He sees strange histories where the uninstructed sees only a blank page. Nothing created is to such a man without interest; for whether he has investigated it or not he knows by analogy that it is worth investigation; "everywhere he sees significances, harmonies, laws, chains of cause and effect endlessly interlinked, which draw him out of the narrow sphere of self-interest and self-pleasing into a pure and wholesome region of joy and wonder." And the more the student of natural history knows of the wonders of creation, the more truly devout he must needs become. As Herbert Spencer has said, "Devotion to science is a tacit worship—a tacit recognition of worth in the things studied, and by implication in their Cause. It is not a mere lip-homage, but a homage expressed in actions—not a mere professed respect, but a respect proved by the sacrifice of time, thought, and labour."* To which let me add the eloquent words of Charles Kingsley, from his description of the "perfect naturalist":—"He must be of a reverent turn of mind also; not rashly discrediting any reports, however vague and fragmentary: giving man credit always for some germ of truth, and giving nature credit for an inexhaustible fertility and variety, which will keep him his life long always reverent, yet never superstitious; wondering at the commonest, but not surprised by the most strange; free from the idols of size and sensuous loveliness; able to see grandeur in the minutest objects, beauty in the most ungainly; estimating each thing, not carnally, as the vulgar do, by its size, or its pleasantness to the senses, but spiritually, by the amount of divine thought revealed to him therein; holding every phenomenon worth the noting down; believing that every pebble holds a treasure, every bud a revelation; making it a point of conscience to pass over nothing through laziness or hastiness, lest the vision once offered and depised should be withdrawn; and looking at every object as if he were never to behold it again."†

Of the infinite and varied delights to the student of Natural History himself supplied by his studies I might say much more; but what need is there for me to do so? Those who wish to know what a true naturalist can say on the subject have only to reach down Charles Kingsley's "Glaucus" from their bookshelves, and they will find the delights and fascinations of

* Education, by Herbert Spencer, p. 51, 1861 edition.
† Glaucus, by Charles Kingsley, p. 38, 1858 edition.

Natural History studies set forth so gracefully and forcibly, that if they are not naturalists already, they may rely on becoming so. I should like to see every boy and girl in this country in possession of this charming book.

It would be easy to compile a long list of benefits which the work of Naturalists has conferred on their fellows. But it is unnecessary in a society like this ; though, even here, where so much encouragement is given to the employment of the microscope, it may not be amiss for the younger members to be reminded that to the use of that invaluable instrument the world owes the researches of Berkeley among the Fungi, and Dallinger and Drysdale's wonderful discoveries concerning the life history of Monads.

For the sake of those who must have a utilitarian reason for everything, I will occupy a few more minutes in giving a short account of Mr. Darwin's last published researches as an illustration of the usefulness of Natural History studies generally, and to show that, where we least expect it, valuable results, of benefit to mankind in general, are yielded by the observations of the working Naturalist.

Most people know the common earth-worm by sight, and if they have not made its acquaintance as a useful adjunct to a day's angling, they have probably done so in their garden, where it is usually regarded as an unmitigated nuisance, to be killed and got rid of in some way or other. Mr. Darwin, with the care with which all his many and valuable observations have been made, has now extracted from this "common object" a mass of information which ought to ensure the prolonged longevity of earth-worms all over the world. He has shown that more than ten tons of dry earth annually passes through the bodies of the worms, and is brought by them to the surface on each acre of land in many parts of England. This large quantity of soil is subjected, as it passes through the worms' bodies, to the action of an acid secreted by the worm having a solvent influence on the soil, and as many of the particles of soil consist of morsels of rock in a non-disintegrated condition this acid assists in breaking them up into still smaller particles, so that they are rendered available for the food of plants. During mild winter months, on the surface of lawns and all over plots of ground left undug for any length of time, evidences of the earth-worms' industry are always to be found by those who look for them. These worm-casts are in most soils surprisingly large in amount; they are often one-fifth of an inch in thickness in a single year (0·2in.) This large quantity of soil, pulverised to the minutest degree, is so placed by worms as to be exposed to the action of air, whence it absorbs oxygen, an important article of food for plants. The worms are continually consuming a good deal of decaying vegetable matter, and mixing it with the soil taken into their bodies, from which they probably derive some nutriment. But the advantage of their labours to themselves is as nothing compared with the benefits they confer on us. They are the chief manufacturers of the rich treasures of mould which form an important part of the fields and gardens of this and other countries. They are unceasingly burrowing beneath the surface, and opening channels through which air and moisture find their way into the soil, and thus carrying on the cultivation of the soil in an unseen and too generally unrecognised manner, supplementing the work of the ploughman and often surpassing the effects of our most approved appliances. Every gardener knows the value of fine soil for a seed bed of any kind, and where he is about to sow seeds he usually takes immense pains to get the soil on the surface as fine as possible, so that the conditions of warmth and moisture may be favourable for germination. Mr. Darwin's researches show us that earth-worms are unceasingly pulverising the surface soil in a manner we can but feebly imitate, and on a scale so large and important to the interests of mankind that one rises from the perusal of this book with the firm conviction that this much-despised creature, which is ruthlessly destroyed by most people whenever opportunity offers, is really one of the most useful of living things. I will not weary you with any statement of the detailed experiments made by our great master, Mr. Darwin, to ascertain the extent of the beneficent labours of the despised earth-worm, but I will conclude what I have to say on the subject by recommending you one and all to read his latest book and profit by its manifold lessons, and especially to imitate, as far as you have the power and opportunity, his example as a patient. unwearied, and accurate observer.

I will detain you only a few minutes longer with a short survey of the work of our Society during the past year, which I am bound to say is satisfactory in extent and character. I must congratulate the members on the valuable papers and addresses delivered to the Geological Section—thanks to the help of many able men, and the admirable arrangements of the chairman and secretary of the section. At these meetings connected instruction by specialists has been given by which many must have profited. In microscopical work precedence must be given to the valuable labours among the Desmideæ of Mr. A. W. Wills, who has added to the number of British species and found many other kinds of great rarity. He has also enriched the Society's cabinet by the gift of fourteen slides on which a large number of Desmids are beautifully mounted. Mr. Bagnall has not only served the Society as its Hon. Librarian, but has found time to pursue his botanical studies, of which he has given us the benefit at many of our meetings. He has also been devoting a good deal of attention to the preparation of his "Flora of Warwickshire," a work on which he has been lovingly engaged for years past, and on which he has bestowed a large portion of his precious leisure hours. This Flora, as you are aware, is being published monthly in the "Midland Naturalist," but I trust the time is not far distant when it will be published separately in an enduring form, and will thereby perpetuate a name deservedly honoured by us, and which I venture to think will be equally honoured by our posterity. I regard it as a duty incumbent on every member of this Society to buy a copy of this book, and it would hasten its publication if a sufficient number willing to do so would send in their names as subscribers. Its probable cost will be from 7s. to 8s. It may be less, I do not think it will be more.

Fungology has for the first time for some years had a good deal of attention from our members, foremost among whom I must name our Hon. Sec., Mr. W. B. Grove, B.A., who has exhibited a large number of specimens and read instructive papers describing them. Our venerable corresponding member, the Rev. M. J. Berkeley, F.R.S., has communicated a paper on "Underground Fungi," and Dr. M. C. Cooke, not only attended our first Fungus Foray—the commencement of what, I trust, may prove to be a long series of annual gatherings devoted to a like object, and which I hope may eventually be of equal value and interest with those of the Woolhope Club—but he contributed a paper on the occasion full of good advice.

Ornithology has had an excellent exponent in Mr. Chase, portions of whose wonderful collection of British Birds, characteristically mounted, have been exhibited publicly on several occasions, while at our meetings he has read us valuable papers which he has illustrated by a great wealth of specimens.

We have missed the presence of our energetic member, Mr. H. E. Forrest, who for a long time worked most assiduously among the microscopic objects of Fresh Water Life. He has removed to a distance where he has been stirring up an interest in the subject by popular lectures, and I trust during the coming year we may be favoured with some communicated paper from his pen. Mr. Levick has not startled us by any discoveries equal to his find of 1880—*Leptodora hyalina*,—but doubtless he has a good reserve of surprises for his presidential year in that marvellous aquarium of his, which has yielded so many rare and curious objects for our meetings.

Dr. Marshall's report on *Funiculina* is unquestionably the most important paper read before the Society during the past year; and Mr. W. P. Marshall's drawings illustrating it are among the very best produced by our members. I regard it as honourable in the highest degree to our Society that it has undertaken to worthily reproduce these drawings, and feel sure that future naturalists will find them valuable aids to the study of the interesting organisms to which they relate.

There are many other topics to which I ought to allude, but the clock warns me to be brief. I will therefore only urge those who have not yet contributed towards the expense of furnishing our room in this college to do so at once according to their means. The total expenditure has been £269, of which £194 have been subscribed by a portion only of the members. The balance £75, if subscribed *pro rata* by those who have not yet contributed to the fund, would be only a small sum each, and I trust our treasurer will, at our next annual meeting, have the pleasure of reporting that he has received the whole amount now owing by the Society.

A large sum has been expended in the purchase of valuable books, by which the Library has been greatly enriched. If our funds were larger our Library would grow more rapidly in extent and usefulness; and if more members would subscribe an additional half-guinea annually to the Apparatus Fund our Microscopes could be increased in number to our mutual advantage and convenience. I feel sure it is only necessary for the attention of many of our members to be directed to this subject to ensure an increase in the amount of the subscriptions.

I must now bring my remarks to a close. We enjoy a great privilege in being permitted to hold our weekly meetings in this noble College. If we are true to our convictions of the value of Natural Science studies we shall each one of us do our utmost to induce others to join our ranks and participate in this and our other privileges, and we shall never rest content until our numbers are largely increased, and the study of natural objects has become a pursuit and a passion to hundreds in this busy town who at present know nothing about them.

TWENTY-THIRD ANNUAL REPORT

OF THE

BIRMINGHAM

NATURAL HISTORY AND MICROSCOPICAL SOCIETY,

READ AT THE

ANNUAL MEETING, HELD FEBRUARY 7TH, 1882.

The Committee have to record a year of quiet progress. The use made by the members of the advantages which the Society now offers is on the whole satisfactory. The change which is most felt and most appreciated is the power of obtaining access to the Society's library and apparatus every day. Many members value highly the increased opportunities of holding friendly converse, and of introducing friends and visitors from a distance, which are thus afforded them.

The Friday evening meetings, which were begun at the end of the year 1880 for the purpose of affording a means whereby instruction in the elementary branches of science and in practical microscopical manipulation might be provided for the younger members, were continued throughout the working portion of last year, and gave every satisfaction to those who attended them. The Committee feel it their duty to say that the usefulness both of these meetings and of the daily opening of the Society's room is owing in great measure to the kind and genial services of the Sub-Curator, Mr. W. H. Cox.

The annual Conversazione was again held in the Town Hall last year and was thoroughly successful, being the most complete exhibition of Microscopical and Natural History objects which the Society has ever been able to get together.

The attendance was large and highly appreciative, Mr. Chase's magnificent collection of birds deservedly attracting a considerable share of praise, second indeed only to that bestowed upon the microscopical display.

During the year there have been two Day Excursions—on Easter Monday to Coventry, and on Whit-Monday to Church Stretton. There have also been Half-day Excursions to Bilston, Wilmcote, Earlswood, Alvechurch, Hampton, Harborne, Bromsgrove, and Olton. Besides these, on October 8th the first Fungus Foray was made by the Society to Sutton Park, under the guidance of Dr. M. C. Cooke, M.A.

The Marine Excursion took place, as was suggested in the last report, to Oban, in the Western Highlands. It extended from July 1st to July 12th, and proved a great success, quite equal to the previous excursions in interest. Thirty-two members joined, including Dr. Thos. Wright, President of the Midland Union, and Mr. Egbert de Hamel, Ex-President of the Tamworth Society; there were also several ladies. A little steamer—the "Curlew"—was chartered for a week, and dredging operations were carried on daily in the Bay of Oban and the vicinity. A most interesting and beautiful series of animals was obtained, which are now receiving attention at the hands of the members, and a portion of the reports—embracing the Pennatulida—has already been presented by Professor A. Milnes Marshall and Mr. W. P. Marshall. Those members who did not join in the dredging had good opportunities of botanising and geologising in a series of excursions to the principal places of interest in the neighbourhood. On the evenings of July 3rd and 10th, Dr. Wright gave, by request, two pleasing addresses "On the Basaltic Formations of Staffa and Iona," and "On Glaciation." In the evenings microscopical demonstrations were given by Professor T. W. Bridge, Messrs. W. P. Marshall, W. R. Hughes, and G. W. Tait. By the courtesy of Mr. R. H. Scott, of the Meteorological Office, telegrams were received daily, giving the weather-forecasts for the morrow, which greatly assisted the members in making their arrangements.

The Committee hope that an equally successful excursion may be made to some other place of interest during the present or next year.

The Meeting of the Midland Union of Natural History Societies in the past year was held at Cheltenham on June 16th, when the members were cordially and hospitably entertained by the Cheltenham Natural Science Society.

The Committee have been much concerned respecting the falling off in the circulation of the "Midland Naturalist." It will be remembered that this Journal was established by the Council of the Midland Union at their first meeting in October, 1877, and the first number was issued in January, 1878; consequently it is now in the fifth year of its existence. From information received from the publishers it appears that the "Midland Naturalist" now mainly relies upon subscribers in London, and that it receives very meagre support both in Birmingham and among the Societies forming the Union. Feeling that the interests of this Journal, which was suggested and set on foot chiefly by some of the members of this Society, are greatly bound up with the interests of the Society, they take this opportunity of earnestly impressing upon every member the duty of subscribing to it. The Committee acknowledge gratefully the valuable services given to the "Midland Naturalist" by the Editors, and will gravely consider during the year the best means of setting the publication on a firm and successful basis.

It is the sorrowful duty of the Committee to record the loss, by death, of one of the oldest and most esteemed members, Dr. William Hinds, who was one of the founders of the Society, and its first President. His kind courtesy and gentle manners have left a lasting impression upon those who were intimate with him. The Society is much indebted to his representatives for the gift of his herbarium, which will prove useful to the botanical members for reference, and will, it is hoped, be the nucleus of a large local herbarium, such as the Society ought to possess.

At the end of the year 1880 the Society numbered 371 members, including five Honorary Vice-Presidents, twenty-nine corresponding members, five life-members, and ten associates. Sixty new members have been elected, including Dr. T. Wright, F.R.S., and Mr. Egbert de Hamel as corresponding members, and six associates. Two associates have passed the age fixed as the limit of their privilege, and forty-six members and one associate have either died or resigned. The total number of members and associates is now 384, so that there has been a net increase of thirteen.

Eighteen Committee Meetings and eleven Sub-Committee Meetings have been held, and the attendance has been as follows :—

		Summoned.	Attended.
President—Mr. E. W. Badger		26	3
Vice-Presidents	Mr. J. Levick	29	18
	Mr. T. H. Waller	26	14
Ex-Presidents	Mr. W. R. Hughes	29	18
	Mr. W. Graham	29	18
	Mr. E. Tonks	21	6
	Mr. W. Southall	29	2
Treasurer—Mr. C. Pumphrey		29	14
Librarian—Mr. J. E. Bagnall		29	20
Curators	Mr. R. M. Lloyd	23	19
	Mr. H. W. Jones	19	8
Sec. Biol. Section—Mr. J. F. Goode		29	20
,, Geol. ,, —Mr. A. H. Atkins		20	16
Hon. Secs.	Mr. J. Morley	29	28
	Mr. W. B. Grove	29	17

Elected Committee.

	Summoned.	Attended.
Mr. S. Allport	26	7
,, W. G. Blatch	26	16
,, T. W. Bridge	26	11
,, R. W. Chase	20	16
,, W. J. Harrison	20	9
,, A. W. Wills	20	10

During the year there have been twenty-six General Meetings, with an average attendance of 31·5, at which the thirteen following papers have been read :—*

* The titles of other papers, read at the sectional meetings, will be found on pages xxiv. and xxvi.

On Photo-Micrography	G. E. Davis, F.R.M.S.
On some singular Water-worn Excavations, called the "Butter-tubs," on the slope of Stag Fell ..	W. P. Marshall, C.E.
Museums in relation to their value in Manufacturing Centres ..	W. G. Fretton.
On the Scope of a Provincial Museum	T. W. Bridge, M.A.
The Marvels of Pond Life (illustrated by the oxy-hydrogen lantern)	J. Levick.
Pasteur's Experiments on Bacteria	T. W. Bridge, M.A.
Fresh-water Aquaria	R. M. Lloyd.
Notes on *Bopyrus squillarum* ..	W. R. Hughes, F.L.S.
Report on the Echinoderms dredged during the Falmouth Excursion, 1879	T. W. Bridge, M.A., and W. R. Hughes, F.L.S.
Underground Fungi	Rev. M. J. Berkeley, M.A., F.L.S.
On some Deep-sea "Challenger" Soundings	J. F. Goode.
On a Dragon-Fly	Silvanus Wilkins.
On the Pennatulida dredged in the Oban Excursion, 1880	A. Milnes Marshall, M.A., D.Sc., and W. P. Marshall, C.E.

The following were the chief specimens exhibited at the General and Sectional Meetings throughout the year. Those marked with an asterisk (*) are new to Warwickshire.

Mr. A. H. Atkins, *Meristella tumida*, in which the spiral calcareous supports of the arms had been developed by hydrochloric acid; *Orthis Budleighensis*, in a quartzite pebble from the Bunter beds of Kinver Edge (new to the Triassic formation); and a collection of Fossil Plants from Wyre Forest.

Mr. J. E. Bagnall, (Phanerogams):—a fine series of the aquatic Ranunculi of Warwickshire; *Anemone nemorosa*, *forma purpurea*, from Kingsbury Wood; *Euonymus Europæus*, and *Lathyrus sylvestris*, from Chesterton Wood; *Samolus Valerandi* and *Trifolium fragiferum*, from Itchington; **Artemisia vulgaris*, var. *coarctata* (*Forcel*); *Prunus avium*, from Solihull; *Trifolium filiforme*, *Carex axillaris*, and *C. elongata*, from near Berkswell;

Carex riparia, from Sutton Park; *Scirpus acicularis* and *Peplis Portula*, from Olton Reservoir; **Rubus hemistemon*, from Cornels End; *Scirpus multicaulis*, from Coleshill; *Salix cinerea*, showing passage of stamens into carpels; *Salix Hoffmanniana*, from Freasley; *Lotus angustissimus*, from East Cornwall; *Carex frigida*, from Balmuto; *Orchis purpureus*, from the Wye Downs; *Alisma lanceolata*, from Bristol; *Rubus hirtifolius* and *Pyrus Briggsii*, from Devonshire; *Isnardia palustris*, from South Hants; *Urtica pilulifera* from Kew; **Agrostis nigra* (Withering), from Berkswell. (Cryptogams, Mosses):—*Scleropodium cæspitosum*, from near Tettenhall; *Gymnostomum tenue*, from Olton Reservoir; *Fissidens exilis*, *F. incurvus*, and *Mnium punctatum* (in fruit), from New Park, Middleton; *Mnium subglobosum* (in flower), *Polytrichum formosum*, and *Hypnum striatum*, from Kingsbury Wood; *Hypnum irriguum*, from Sutton Park; *Hypnum filicinum*, from Freasley; *Physcomitrium pyriforme* (in fruit), from near Seckington; *Sphagnum auriculatum*, and *S. subsecundum*, from Cut-throat Coppice, Solihull. (Hepaticæ):—*Scapania curta*, from Cornel's End; *Cincinnulus Trichomanis* (in fruit) and *Lophocolea heterophylla* from Kingsbury Wood; *Pellia epiphylla*, **Jungermannia connivens*, *J. bicuspidata* (all growing and in good fruit), and *J. inflata*, from Sutton Park. (Characeæ):—**Chara contraria*, var. *hispidula*, from Sow Waste; and **C. Hedwigii*, from Knowle; *Nitella flexilis*, from Olton. (Fungi):—*Agaricus pantherinus*, *A. rubescens*, *A. candicans*, *A phyllophilus*, *Lactarius subdulcis*, *L. zonarius*, *Marasmius urens*, *Cortinarius hinnuleus*, and *C. tabularis*, from near Kenilworth; *Agaricus alcalinus*, **A. heteroclitus*, *A. stellatus*, **Cyphella capula*, *Tremella foliacea*, and *Peziza aurantia*, from Sutton Park; *Agaricus asper*, *A. phalloides*, *A. nebularis*, *Hygrophorus coccineus*, *Russula fœtens*, *R. cyanoxantha*, *R. fragilis*, *Cortinarius bulbosus*, *C. decipiens*, *C. elatior*, and **Nyctalis parasitica*, from Cut-throat Coppice, Solihull; *Agaricus pantherinus* and *Russula emetica*, from Stratford-on-Avon; **Mitrula paludosa*, from near Packington; *Ozonium auricomum* (Greville), an abnormal state of some Polyporus; and *Polyactis cana*, a microfungus growing on Sphagnum.

Mr. W. G. Blatch, the following Coleoptera and Heteroptera:—**Achenium humile*, from Salford Priors; and *Aneurus lævis*, from Bewdley Forest, new to the district; *Elater balteatus*, **Gymnusa variegata*, and **Scydmænus exilis*, from Sutton Park; **Endomychus coccineus*, **Choragus Sheppardi*, and **Lathridius rugosus*.

Mr. T. Bolton, *Triticella pedicellata*, showing the spermatozoa; *Œcistes janus*, recently discovered in Scotland, from Dundee; an Infusorian, **Raphidomonas semen*, from Sutton, new to Great Britain; *Floscularia trifolium*, found by Mr. Wagstaff near Birmingham, discovered for the first time in Scotland in 1880; *Chætophora endiviæfolia*, from Sutton; *Bacillaria paradoxa* from the Birmingham Canal, near Albion; *Syncoryne frutescens*, *Clytia Johnstoni*, *Bugula avicularia*, and *Triloculina trigonula*, from Brighton; *Follicularia Boltoni*, from Evesham; *Limnocodium Sowerbeii*, the recently-discovered fresh-water Medusa, from the Royal Botanic Gardens at Kew; *Pedalion mira: Synchæta pectinata*, from Moseley.

Professor T. W. Bridge, a photograph of *Archæopteryx macrura*, taken from the second recently discovered specimen; the Echinodermata which were dredged during the Society's excursion to Falmouth; specimens of Ascidians and Polychætous Vermes; three specimens of young Hammer-headed Sharks (*Zygæna*), the "Barramunda" (*Ceratodus fosteri*), from Queensland; the Paddle-fish (*Polyodon folium*), the Two-toed Sloth (*Cholopus Hoffmanni*), the Tamandua Ant-eater (*Tamandua tetradactyla*), and *Loris gracilis*.

Mr. R. W. Chase, *Apteryx australis* (male and female), *Apteryx Oweni: Polystichum Lonchitis*, *Asplenium viride*, and *Lycopodium clavatum*, from Perthshire; and very many British Birds in all stages, from the eggs and young to the adult.

Dr. Deane, *Amanita muscaria*.

Mr. J. F. Goode, *Spirogyra quinina*, in conjugation; *Puccinia anemones; Nonionina Barleeana*, a Foraminifer, from sand dredged at Oban; Globigerina and Radioliarian ooze, from the "Challenger" soundings.

Mr. W. B. Grove, a number of Fungi from the neighbourhood, the chief of which were—*Agaricus rutilans*, *A. spectabilis*, *A. nudus*, *A. rhacodes*, *A. maculatus*, *A. laccatus* (purple variety), *A. tener*, *A. cerussatus*, *Bolbitius titubans*, *Hygrophorus virgineus*, *H. miniatus*, *H. psittacinus*, *Cortinarius tabularis*, *Lactarius rufus*, **L. pubescens*, *Russula fragilis*, **R. citrina*, **R. ochroleuca*, *Cantharellus aurantiacus*, *Boletus badius*, **B. luteus*, *Polyporus betulinus*, **P. adustus*, *P. vaporarius*, **P. molluscus*, **P. annosus*, *P. igniarius*, **Trametes inodora*, **Hydnum niveum*, *Thelephora laciniata*, **Tremella foliacea*, **Trichia varia*, *Arcyria punicea*, **Craterium pedunculatum*, **Comatricha Friesiana*, **Chondrioderma difforme*, **Peziza Dalmeniensis*, and *Bulgaria inquinans*: also the following rare species, collected during the Fungus Foray:—**Agaricus chioneus*, **A. echinatus*, and **A. udus*, a species first discovered in Britain in November, 1880, in Epping Forest.

Mr. W. J. Harrison, Palæolithic and Neolithic Flint Implements: large and small varieties of *Lima gigantea* from Barrow-on-Soar: a drawing of a plate of ivory on which the outline of a mammoth had been sketched by some prehistoric man: *Ammonites biplex*, in which the nacreous lustre of the shell was perfectly preserved: a collection of Lias Fossils and Quartzite Pebbles from Moseley, containing *Orthis Budleighensis* and *Modiolopsis Armorici*.

Mr. W. F. Haydon, a section of Porphyrine.

Mr. W. R. Hughes, mounted specimens of *Trichina spiralis*, from the muscles of man and pig; *Bopyrus squillarum*, mounted; *living* specimens of Marine Organisms dredged by the Society at Oban, viz., *Sagartia viduata*, *Caryophyllia Smithii*, *Alcyonidium hirsutum*, *Terebratula caput-serpentis*, *Turritella communis*, *Aporrhais pes-pelicani*, and Barnacles; also the ova of *Bilharzia hæmatobia*, from which the embryos were hatched in the room.

Mr. H. W. Jones, three Crabs from the Orme's Head—*Hyas araneus*, *Porcellana platychiles*, and *Corystes cassivelaunus*.

Mr. J. Levick, *Leptodora hyalina*, from the Warwick Canal, within four miles of Birmingham; a Fungus, *Cyathus vernicosus*, from Aston: *Melicerta annulata*, *M. tyro*, *M. tubicolaria*, *Œcistes* *umbella*, and **Lithamœba discus*, from his own aquarium.

Mr. R. M. Lloyd, section of a species of Bignonia; *Polyporus squamosus*, from Castle Bromwich.

Mr. W. P. Marshall, the Pennatulida (Virgularia, Pennatula, Funiculina), dredged at Oban, with sections and drawings of the same.

Mr. H. Miller, the Sapucaya Nut from Brazil; and a cheap compressorium invented by Mr. H. E. Forrest.

Mr. J. Morley, *Chætophora elegans*, and *Draparnaldia plumosa*, from Sutton.

Mr. C. T. Parsons, *Apteryx Oweni*, and a specimen of the rare Owl Parrot.

Mr. J. W. Pickering, a Fungus, *Cordyceps militaris*, growing upon larvæ; *Stentor niger*, from the Wyre Forest; and monœcious form of *Mercurialis perennis*.

Mr. C. J. Rodgers, flexible Sandstone from India.

Mr. W. Southall, a water-colour drawing of *Ataccia cristata*, a remarkable plant in flower at the Edgbaston Botanical Gardens; Fruit of Caryocar (Butter-nut), from South America; and the following Fungi from Yardley Wood:—*Agaricus asper*, *A. rubescens*, *A. excoriatus*, *A. rutilans*, *A. separatus*, *A. asterophorus*, *Russula emetica*, *R. fellea*, *R. heterophylla*, *R. fragilis*, and *Lactarius subdulcis*.

Mr. E. H. Wagstaff, *Volvox globator*, with yellow resting spores; *Draparnaldia glomerata*; *Stephanoceros Eichhornii*, from Harborne; and *Cristatella mucedo*, from King's Norton.

Mr. T. H. Waller, microscopic section of Obsidian from Mexico.

Mr. C. J. Watson, a bottle of gas (obtained from confervoid growth in a marine aquarium) which was shown to consist chiefly of oxygen.

Mr. S. Wilkins, *Cuscuta Europæa* (Greater Dodder), and a collection of Fungi, including *Clathrus cancellatus*, from near Axminster.

Mr. W. H. Wilkinson, a collection of Sea-gulls from Flamborough Head; and *Dipsacus pilosus*, from Stafford Castle.

Mr. A. W. Wills, *Cosmarium cambricum*, *C. coronatum*, *Staurastrum anatinum* (all three new to science), *Closterium obtusum* (hitherto recorded only in Ireland), *Cl. pronum* (new to Britain), *Micrasterias denticulata*, var. *hemoides*; *Chantransia investiens*, and *Leptothrix tinctoria*, from Penzance; *Spirogyra inflata*, from Bangor; and *Sarcina ventriculi*.

There have been two lectures, specially adapted for a general audience, which were largely attended:—

The Moon and her influence on the Earth ..	S. H. Parkes.
Scenes in India	J. Levick.

(Both illustrated by the oxy-hydrogen lantern.)

J. MORLEY,
W. B. GROVE, B.A., } Hon. Secretaries.

BIOLOGICAL SECTION.

There have been ten meetings of the Section, under the presidency of the Chairman, Mr. A. W. Wills, the average attendance at which has been thirty-two, showing a steady improvement and an increased interest in the proceedings.

Seven papers have been read, as follows:—

On the Migration of Birds	R. W. Chase.
On a Nest Building Fish	Silvanus Wilkins.
On some New Species of Desmidieæ	A. W. Wills.
On the Sea-gulls of Flamboro' Head	W. H. Wilkinson.
On the Birds of the Farne Islands	R. W. Chase.
On the Auditory and Vocal Organs of Fishes	Professor T. W. Bridge, M.A.
Note on Agrostis nigra of Withering as a Warwickshire Plant	J. E. Bagnall.

The work of the Section has been well sustained throughout, and a number of rare and valuable specimens in all departments have been exhibited.

The Botanical portion, as usual, has been well supported, and many interesting specimens, both of Cryptogams and Phænogams, have been exhibited by Messrs. Bagnall, Grove, Southall, and others, including some fine collections of Fungi.

The Zoological part of the proceedings has been rendered more than usually interesting by a number of valuable exhibits, among which may be mentioned—rare and curious fishes by Professor T. W. Bridge; a fine collection of Birds from the Farne Islands, with nests, eggs, and young in various stages, by Mr. R. W. Chase. The Section is also indebted to Mr. W. H. Wilkinson for a similar series illustrating the Sea-gulls of Flamborough Head. Entomology has been represented solely by Mr W. G. Blatch, who has exhibited some rare Coleoptera and Heteroptera, new to the district, proving that the neighbourhood around Birmingham is not so barren as is generally supposed, and that many discoveries are yet to be made by diligent and systematic workers. It is to be hoped that some of our young associates will be induced to take up this most attractive and fascinating pursuit.

The Microscopic Specimens have been a most prominent feature in the proceedings, our Chairman, Mr. A. W. Wills, having exhibited many beautiful and rare species of Desmidieæ, three of which, viz., Cosmarium cambricum, Cosmarium coronatum, and Staurastrum anatinum are new to science. Many rare and exquisite marine and fresh-water organisms have also been exhibited by Messrs. Bolton, Levick, and others.

The past season may on the whole be considered encouraging, and the future looked forward to with much satisfaction.

If some of the members would take up a special subject and systematically follow it out, the work of the Section would be rendered much more useful, and facts might be recorded which in the end would, no doubt, lead to important results.

JOHN F. GOODE,

Hon. Sec., Biological Section.

GEOLOGICAL SECTION.

There have been eleven meetings of this section during the year, with an average attendance of thirty-eight.

The following papers have been read :—

The Rhætic Formation, with its Bone Bed and the First Mammal.	W. J. Harrison, F.G.S.
The Triassic Rocks of the Midland Counties	A. H. Atkins, B.Sc.
The Lias Formation, with especial reference to Warwickshire ..	Rev. P. B. Brodie, M.A., F.G.S.
The Geology of the Glacial Epoch ..	Rev. H. W. Crosskey, F.G.S
How to Work in the Archæan Rocks	Dr. C. Callaway, F.G.S.
The Government Geological Survey: its history, progress, and present state	W. J. Harrison, F.G.S.
Zone Relations in Crystals	C. J. Woodward, B.Sc., F.G.S.

The first four papers were the continuation of a series begun in the preceding year for the purpose of describing the chief features of the various formations, especially in relation to their development in the Midland Counties. The meetings have been very successful, owing in great measure to the influence of Mr. W. J. Harrison, the chairman of the year.

Five meetings have been held on Friday evenings for educational purposes. On April 8th a paper by Mr. W. J. Harrison was read on "The Uses of Geological Knowledge." On November 11th and December 9th Mr. T. H. Waller described the process of making Microscopical Rock Sections, and the methods of identifying the minerals they contain. The other two evenings were occupied by conversation.

There have been two Excursions for Geological purposes only :—June 25th, to the Lias Sections at Wilmcote; July 16th, to the Drift Beds and Boulder Clay near Harborne.

A. H. ATKINS, B.Sc., Hon. Sec.

CURATOR'S REPORT.

During the past year, four cabinets for microscopic objects have been provided, and the following slides have been presented to the Society:—fourteen slides of Desmids, by Mr. A. W. Wills; eight slides, explanatory of the embryology of the chick, by Mr. J. F. Goode: twenty-four insects, mounted by Mr. F. Enock, by Mr. C. T. Parsons; six rock sections, etc., by Mr. W. J. Harrison; and twelve preparations showing the viviparous nature of Ophiocoma neglecta, etc., by Mr. F. W. Sharpus, of London, per Mr. W. R. Hughes. Thus while the number of slides is not very great the quality is exceptionally good.

The only other specimens added to the collection of this Society during the past year have been those contained in the seventeen volumes of the Herbarium of the late Dr. William Hinds, which has been kindly presented by his representatives.

The microscopes are in as good order as reported last year, and have been extensively used at the various meetings; but at times a great want has been felt on account of their limited number, and it is hoped that during the present year one or two others not inferior to the Crouch or Swift instruments will be purchased. More lamps are also very much wanted, and it is suggested that a number of suitable simple gas lamps be bought, they being far cleaner, safer, and less cumbersome than paraffin ones, and ready means of connection being at hand in the usual meeting-room. Side reflectors are also required for the Crouch and Swift microscopes, as also a few other small accessories, such as micrometers, and a micro-spectroscope. Six objectives, formerly belonging to the late Dr. William Hinds, have been purchased by the Society.

R. M. LLOYD, Hon. Curator.

LIBRARIAN'S REPORT.

The Librarian is able to report that the state of the Library is satisfactory, and that some of the volumes which were missing at the time of the last report have been returned during the past year.

The increased facility for the issue of the books of the Library has brought about a measure of the good results anticipated in the last report, the number of books issued during the present year being nearly double that of last year. It is only right to state that this is mainly due to Mr. W. H. Cox's services. The issue of books for the past year has been as follows:—Botanical, 62; Conchological, 14; Entomological, 24; General Literature, 144; Geological, 30; Microscopical, 87; Zoological, 45; total, 406; increase, 167. Although in this analysis of the issue of books a greater ratio occurs under the head of general literature, it must be remembered that some of the books, such as the valuable works of Darwin, Huxley, and Lubbock, which cannot be placed in any special class, and are, therefore, placed here under the head of General Literature, are as truly scientific as the most special book in any branch of science.

The Librarian has only one complaint to make, that is that some few of the members keep the books too long. This may be an injustice to other members, who are thereby sometimes inconvenienced and annoyed.

During the past year your Committee have constantly borne in mind the wants of the Library, and have from time to time materially increased its value and usefulness. The following works have been purchased:—

Hepaticæ, Lindenberg, 2 vols., quarto.
Linnean Society's Proceedings, vol. xvii., Botany.
Hepaticæ Europeæ, Dumortier, 1 vol., 8vo.
Freaks and Marvels of Plant Life, M. C. Cooke, 1 vol., 12mo.
Illustrations of British Fungi, M. C. Cooke, 8vo., parts 1—6.
Clavis Synoptica Hymenomycetum Europæorum, Cooke and Quelet, 1 vol., 12mo.
The Power of Movement in Plants, C. Darwin, 1 vol., 12mo.
Sphagnaceæ of Europe and America, R. Braithwaite, M.D., 1 vol., 8vo.
Manual of British Botany, Eighth Edition, 1881, C. C. Babington, M.A., F.R.S., 1 vol., 8vo.
Synopsis Methodica, Joannis Raii, Second Edition, 1 vol., 12mo.

Catalogus Plantarum Angliæ, Joannis Raii, M.A., 1 vol., 12mo.
Gardens of the Sun, Burbidge, 1 vol., 8vo.
British Beetles, Rye, 1 vol., 12mo.
Larvæ of British Lepidoptera, Wilson, 1 vol., 8vo.
Libellulinæ Europeæ, Charpentier, 1 vol., 4to.
The Polar World, A. Hartwig, 1 vol., 8vo.
Island Life, A. R. Wallace, 1 vol., 8vo.
A Year at the Shore, P. H. Gosse, 1 vol., 12mo.
Tenby, P. H. Gosse, 1 vol., 12mo.
Rambles on the Devonshire Coast, P. H. Gosse, 1 vol., 12mo.
Morocco and the Great Atlas, Hooker and Ball, 1 vol., royal 8vo.
The Brain as an Organ of the Mind, Bastian, 1 vol., 8vo.
Manual of Palæontology, Nicholson, 2 vols., 8vo.
The Entomostraca of the Cretaceous Formation of England, T. Rymer Jones, 1 vol., 4to.
Phillips' Mineralogy, Brooks and Miller, 1 vol., royal 8vo.
The Study of the Rocks, Rutley, 1 vol.
Monograph of the Permian Fossils, W. King, 1 vol., 4to.
Volcanoes, Judd, 1 vol., 8vo.
Quarterly Journal of Microscopical Science, ten parts to complete the volumes in the Library.
The Microscope and its Revelations, 1881, Carpenter, 1 vol., 12mo.
The Birds of Europe, Bree, 5 vols., royal 8vo.
Linnean Society's Proceedings—Zoology, vol. xvii.
British Sessile-eyed Crustacea, Bates and Westwood, 2 vols., 8vo.
Zoological Atlas, Dr. McAlpine, 1 vol., 4to.
Marine Polyzoa, Hincks, 2 vols., 8vo.
Hydra, Kleinenberg, 1 vol., 4to.
Report of the Scientific Results of the Exploring Voyage of H.M.S. "Challenger," 3 vols., 4to.
Zoology, Nicholson, 1 vol., 8vo.
Fishes of Malabar, Francis Day, 1 vol., fol.
Fishes of Great Britain, Francis Day.
Manual of the Infusoria, W. Saville Kent, parts 1—5.
Fauna und Flora des Golfes von Neapel, Monagraphs I., II., III., IV.
The Ray Society's Volume for 1881.
The Palæontographical Society's Volume for 1881.
Science Gossip, 1881.
Journal of Botany, 1881.
Nature, 1881.
Quarterly Journal of Microscopical Science, 1881.
Midland Naturalist, 1881.

Annals of Natural History, 1881.

Popular Science Review, 1881.

The Zoologist, 1881.

The Entomologist, 1881.

The Entomologists' Monthly Magazine, 1881.

The Geological Magazine, 1881.

The following have been presented :—

Natural History of the Malvern Hills—Migratory Birds, W. Edwards.

The Botany and Geology of the Malvern Hills, Edwin Lees. Presented by Mr. Short.

Journal of the Royal Microscopical Society.

Proceedings of the Scientific Meetings of the Zoological Society of London.

Proceedings of the Leicester Literary and Philosphical Society.

Transactions of the Epping Forest and County of Essex Naturalists' Field Club.

Proceedings of the Natural History Society of Glasgow.

Proceedings of the Birmingham Philosophical Society.

Proceedings of the Nottingham Literary and Philosophical Society.

Archivos do Museu Nacional de Rio de Janeiro, vols. ii. and iii.

J. E. BAGNALL, Hon. Librarian.

TREASURER'S REPORT.

The total received for Ordinary Subscriptions for the past year exceeds that for last year by £8 6s. 6d., but as there have been no Life Subscriptions, and less has been received in advance (for 1882), also a reduction in Subscriptions for Apparatus, the total has been £8 3s. less than 1880.

Nothwithstanding a considerable sum of previous arrears has been collected this year, the sum now due—£66 6s.—is nearly £10 in excess of last year; but as only twenty-four cases extend beyond 1881 it is probable that the larger portion of this debt will be paid.

The Furnishing Fund has realised £193 18s. 6d., and the Expenditure has been £267 17s. 11d. The balance deficit is £73 19s. 5d.

The Apparatus Fund has not met the expenditure by £7 0s. 6d.

The outlay on Books is nearly the same as last year; but that is a considerable advance on previous years.

The Sub-Curator's Salary is a new expenditure; but the advantages of an open room, etc., are so great, that it is not likely to be discontinued.

Postage is a very heavy item, and it is worth consideration what can be done to reduce it.

The Soirée accounts not being completed do not appear this year, but the balance of deficiency is not expected to be large. The difficulty of prompt settlement is due to the delay in obtaining payment for tickets sent on approval. It appears to the Treasurer that it would be better to have a higher rate of Subscription and let each member be entitled to a free ticket to the Soirée. The outstanding liabilities are very small.

It will probably be thought right to print the list of donors to the Furnishing Fund; and benefit would probably be derived if the actual payment of each member for subscriptions during the year was also printed in the Report.

The result of the year is that the balance brought forward of nearly £20 in the Treasurer's hands will be replaced by a balance of nearly £12 on the other side of the account.

CHARLES PUMPHREY, Hon. Treasurer.

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T. H. HUXLEY, LL.D., F.R.S.

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HERBERT SPENCER.

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SILVANUS WILKINS.

LIST OF THE MEMBERS

OF THE

BIRMINGHAM

NATURAL HISTORY AND MICROSCOPICAL SOCIETY,

JANUARY. 1882.

Those Members whose names are marked with (P) have been Presidents of the Society; those with (L) are Life Members: those with (C) are Corresponding Members; those with (*) are Guinea Subscribers; and those with (†) are Subscribers to the Apparatus and Library Fund.

Name.	Address.
Abrahall, J.	2, Copely Hill, Gravelly Hill.
Adams, J.	Highfield Road, Harborne.
†Adams, Rupert	Grosvenor Road, Handsworth.
Albright, G. S., B.A.	Mariemont, Edgbaston.
Allday, Edmund	Park Road, Solihull.
Allday, John	The Oaks, Handsworth Wood.
Allday, William	330, Coventry Road, Birmingham.
Allen, W. S.	35, Waterloo Street.
Allport, Samuel, F.G.S. (*P*) ..	The Mason College.
Allport, S.B.	Whittall Street.
Anderton, J.	99, Suffolk Street.
†Anthony, John, M.D., F.R.C.P., F.R.M.S.	Greenfield Terrace, Edgbaston.
Antrobus, Alfred	Old Chester Road, Erdington.
Antrobus, P.	Church Hill, Handsworth.
Atkins, A. H., B.Sc.	King Edward's School.
Atkins, E.	Woodside, Handsworth Wood.
Austin, Josiah	Nechells House, Nechells.
Avery, Alderman, J.P.	Church Road.
Babington, C. C., M.A., F.R.S.. (*Hon. V.P.*)	Cambridge.
Badger, A. Bernard	Oxford Road, Moseley.

†Badger, E. W. (*P*)	Office of *Midland Counties Herald.*
Badger, E. W., jun., M.A. ..	Oxford Road, Moseley.
Bagnall, Jas. E.	84, Witton Road.
Bailey, T. H.	Perry Pont, Perry Barr.
Bain, Rev. W. J.	Mount Pleasant, Bilston.
Baker, Harold	101, Gough Road, Edgbaston.
Ball, Henry	74, Gough Road.
Barclay, Hanbury	Anchor Tube Co., Gas Street.
Barclay, Thomas	Moseley Road.
Barratt, J. O. W., B.Sc. ..	Exeter Row.
Bartleet, R. S., J.P.	The Shrubbery, Redditch.
Baxter, J. H.	15, Alston Street, Ladywood.
Beale, Dr. L., F.R.M.S. (*C*) ..	61, Grosvenor Street, London, W.
Bellingham, B.	205, Wolverhampton Street, Dudley.
Berkeley, Rev. M. J., M.A., F.L.S. (*C*)	Sibbertoft, Market Harborough.
Betteridge, J.	36, Suffolk Street.
†Bevan, Rev. J. O.	72, Beaufort Road.
Birkmire, T.	107, Albert Road.
Blakemore, J.	Oban House, Ladywood Lane.
Bland, T. F.	High Street, Stourbridge.
Blatch, W. G.	Albert Villa, Green Lane.
Boeddicker, G. A.	Ethel Road, Harborne.
Bolton, Thomas, F.R.M.S. ..	57, Newhall Street.
†Bowater, W. H.	110, Lodge Road.
Boyden, Rev. H.	Pershore Road.
Braendlin, F. A.	29, Stamford Road, Handsworth.
Bragge, W., F.S.A	59, Hall Road, Handsworth.
Braithwaite, Dr. (*C*)	The Ferns, Clapham Rise, S.W.
Bridge, T. W., M.A.	The Mason College.
Brittain, H.	Alston Street, Ladywood.
Brittain, Henry	George Street West.
Brodie, Rev. P. B., M.A. (*C*) ..	Rowington, Warwick.
Brown, Wm.	Waterloo Street.
Browne, Montagu, F.Z.S. ..	Leicester Museum.
Bullus, W., M.R.C.S.	High Street, West Bromwich.
Burgess, J. Tom. F.S.A. (*C*) ..	Bath Villa, Worcester.
Burman, R. H.	Lionel Street.
Caldwell, George	34, Worcester Street.
Callaway, C., D.Sc., F.G.S. (*C*)	Wellington, Salop.
Carter, H. J., F.R.S. (*C*) ..	Budleigh Salterton, Devon.

Cashmore, G. T.	11, Albert Road, Handsworth.
Caswell, C. B., F.I.C.	13, George Road, Edgbaston.
Chase, Robert	Great Barr.
†Chase, R. W.	2, Edgbaston Road, Edgbaston.
Chamberlain, Henry John ..	Kenilworth Place, Francis Road.
Chamberlain, R.	Westbourne Road, Edgbaston.
Chavasse, T. F., F.R.C.S. ..	21, Temple Row.
Chittey, E. J.	39, Bennett's Hill.
Clarke, Ann E., M.D.	Hospital for Women, Spark Hill.
Clarke, J. B.	Henley Lodge, Handsworth.
Clarke, T.	187, Moseley Road.
Clayton, F. C.	18, St. James Road.
Cobbold, T. Spencer, M.D., F.R.S. (*Hon. V.P.*)	74, Portsdown Road, Maida Hill, London, W.
Collens, E.	Holly Lane, Erdington.
Collett, Harvey	West Bromwich.
Collins, F. H.	Church Field, Edgbaston.
Collins, G.	Oak Tree Cottage, Prospect Road, Moseley.
Collins, J. T.	Church Field, Edgbaston.
Cooksey, J. H.	West Bromwich.
Corser, Benj.	42, Cherry Street.
†Cotterell, Wm., F.R.A.S. ..	17, Park Street, Walsall.
Cotton, I. J.	10, Great King Street, Hockley.
Cotton, J. W., F.G.S.	Exdale, near Coventry.
Cottrell, J.	176, Ashted Row.
Cox, W. H.	150, Newhall Street.
Cresswell, A. N.	2, York Road, Edgbaston.
Crofts, George	The Cedars, Trafalgar Road.
Crompton, Henry D.	Beaufort Road, Edgbaston.
Crosskey, Rev. H. W., F.G.S. (*P*)	28, George Road, Edgbaston.
Cumberland, T.	Dorset House, Harborne.
Dallinger, Rev. W. H.	Wesley College, Sheffield.
†Davis, Geo. E. (*L*)	Dagmar Villa, Heaton Chapel, Stockport.
Deane, Rev. G., D.Sc. (*P*) ..	Spring Hill College, Moseley.
Druce, G. C., F.L.S. (*C*)	High Street, Oxford.
Dugard, William	Lower Loveday Street.
Duignan, W. H.	Walsall.
†Dussault, A. L.	4, Augusta Road, Moseley.
Edmonds, John	General Cemetery.
Enock, F. (*C*)	Fern Dale, Bath Road, Worthing Station, Surrey.

Everitt, Allen E.	City Chambers, 82, New Street.
Evett, James	The Elms, Handsworth.
Fletcher, Dr. Bell (*L*)	7, Waterloo Street.
Ford, J.	*Chronicle Office*, Wolverhampton.
Ford, William Henry	Beaumont Terrace, Merridale, Wolverhampton.
Forrest, H. E., F.R.M.S. ..	Lloyds Banking Company, Welshpool.
Fowke, F. (*C*)	Thatched House Club, St. James St., London.
Francis, Mrs.	71, Wheeley's Road.
Franklin, C. E.	31, Suffolk Street.
Fraser, Dr. J. (*C*)	Chapel Ash, Wolverhampton.
Fretton, W. G., F.S.A. (*C*) ..	Coventry.
†Fry, Henry A.	117, Gough Road, Edgbaston.
Gibbins, John	13, Arthur Road, Edgbaston.
†Gibbons, W. P.	Athol House, Edgbaston.
Glainville, B. J. (*C*)	Albany Museum, Grahamstown, South Africa.
†Goode, A. C.	Emsley, Greenhill Road, Moseley.
†Goode, J. F.	The Moors, Church Lane, Handsworth.
Goode, J. T.	The Moors, Church Lane, Handsworth.
Goode, Miss	34, Frederick Road.
†Graham, Walter, F.R.M.S. (*P*) ..	Ludgate Hill.
Grant, William T.	The General Hospital, Birmingham.
Greening, Alf. T...	Bath Villa, Stratford Road.
Greenway, J. F.	28, Wheeley's Road.
Griffiths, A. H.	Thornbury, Woodbourne Road, Edgbaston.
Grove, W. B., B.A.	269, St. Vincent Street, Ladywood.
Hadley, Miss A.	Hamstead Lodge, Handsworth.
Hadley, F.	Hamstead Lodge, Handsworth.
Hadley, Phillip	41, Beaufort Road.
Hale, W.	King's Norton.
Hall, A.	Edith Villa, Albert Road.
Hamel, E. de (*C*)	Tamworth.
Handley, E.	Hendra, Church Road, Edgbaston.
Hardiker, W. A.	Albion House, Rookery Road, Handsworth.
†Harding, Rev. Isaac	Smethwick.
Harrison, W. J., F.G.S... ..	Golden Hillock Road.
Harrold, William..	324, Bristol Road.
Hassall, T. H.	Balmain House, Trafalgar Road, Moseley.
Hatton, T. S.	Waterloo Road S., Wolverhampton.
Hawkes, Henry	Northfield.

	Haydon, W. F., F.C.S.	The Exchange.
	Heaton, James	Union Passage.
	Heaton, George, J.P.	Church Hill, Handsworth.
	Heaton, Mrs. George	Church Hill, Handsworth.
*	Heaton, Harry	Harborne House, Harborne.
	Heaton, Alderman, J.P. ..	Courtlands, Edgbaston.
	Heslop, T. P., M.D.	Temple Row.
	Hill, Alfred, M.D., F.C.S. ..	Birmingham.
†	Hill, Frederick	Park Street.
	Hinds, James, M.B. (*C*) (*P*) ..	Halstead, Essex.
	Hinks, T.	Buckingham Street.
	Hobkirk, C. P. (*C*)	7, Arthur St., Fitzwilliam St., Huddersfield.
	Hodgkinson, W. L.	Norwood House, Erdington.
	Holbeche, R. A.	21, Bennett's Hill.
	Hookham, George, M.A. ..	Trafalgar Road, Moseley.
	Hookham, Phillip	King's Norton.
	Hooper, T..	Wylde Green.
	Hopkins, A. N.	110, Bristol Road.
†	Houghton, F. T. S., B.A. ..	313, Moseley Road.
	Howes, Henry	Bristol Street.
	Hughes, W. R., F.L.S. (*P*) ..	Wood House, Handsworth Wood.
	Hughes, Mrs. W. R.	Wood House, Handsworth Wood.
	Hutchinson, A. J.	126, Hockley Hill.
	Huxley, T. H., LL.D., F.R.S., (*Hon. V.P.*)	4, Marlborough Place, St. John's Wood, N.W.
	Huxley, Dr. J. C..	91, Harborne Road.
	Iles, Fred...	Greenhill Road, Moseley.
	Iliff, G. M.	19, Bull Street.
	Impey, R. L.	Waterloo Street.
	Innes, J.	Moseley.
	Jelf, John	Southbourne, Birchfield.
	Johnson, Alfred	7, George Street, Parade.
	Johnson, Miss	Packwood Grange, Knowle.
	Johnstone, George Hope ..	Headingley, Hamstead, Handsworth.
	Johnstone, William F.	24, Westminster Road.
	Jones, George, M.R.C.S.. ..	Newhall Street—41, Hagley Road.
	Jones, H. W., F.C.S., F.R.M.S.	19, Hertford Terrace, Coventry.
	Jones, T. Walter..	Villa Road, Handsworth.
	Jones, W. H.	Livingstone Road, Handsworth.
	Jones, W.	Stephenson Chambers, New Street.
	Keep, J. S..	Park Road, Edgbaston.

Kenrick, G. H.	Maple Bank, Church Road, Edgbaston.
Kent, W. Saville, F.L.S., F.R.M.S. (*C*)	Aston House, St. Stephen's Avenue, Shepherd's Bush, London, W.
Ketley, Charles	7, Belle Vue Terrace, Smethwick.
Ketley, Charles B.	7, Belle Vue Terrace, Smethwick.
Lambert, Streeter	Sunnyside, Ampton Road.
Lancaster, W. J., F.C.S. ..	3, Snowdon Villa, Heathfield Road, Handsworth.
Lapworth, C., Professor ..	The Mason College.
Latham, W. B.	Botanical Gardens.
Lauprecht, Madlle.	34, Frederick Road, Edgbaston.
Leigh, James	King's Norton.
†Levick, John	89, Lime Tree Villas, Albert Road
Lewis, John, F.S.S.	Victoria Road, Harborne.
Lingard, Geo.	Hildathorpe, Park Hill, Moseley.
Linn, D. J.	124, Soho Hill, Handsworth.
Littlewood, W.	West Bromwich.
Lloyd, R. M.	19, Spring Hill.
Lloyd, Jordan, M.B., F.R.C.S...	21, Broad Street.
Lloyd, J., M.B.	Coventry Road.
Lloyd, J. H., B.A.	Edgbaston Grove, Church Road.
Lloyd, Wilson	Wednesbury.
†Lovett, W. J.	Carver Street Works.
Luckett, J.	Great Colmore Street.
Madeley, F.	Ox Hill, Handsworth.
Mapplebeck, John E., F.L.S. ..	Hartfield, Moseley Wake Green.
Marrian, J. R.	Adzor House, Lozells Road.
Marrian, Mrs. J. R.	Adzor House, Lozells Road.
Marris, Councillor	Corporation Street.
†Marshall, W. P. (*P*)	15, Augustus Road.
Marshall, Mrs. W. P.	15, Augustus Road.
Martin, F. W.	Bournbrook Hall.
Martineau, Edgar	Solihull.
Mathews, Wm., M.A., F.G.S...	Harborne Road, Edgbaston.
Mathews, James	Hungary Hill, Stourbridge.
Mathews, Paul, M.A., F.C.S. ..	Minster Precincts, Peterborough.
Maw, George (*C*)	Benthall Hall, Broseley.
Mayo, Miss Beatrice	Elmshurst, Handsworth Wood.
Mayo, R.	Elmshurst, Handsworth Wood.
Merry, E.	Phœnix Works, Catherine Street, Aston.
Middleton, Rev. G.	Bourne College, Summer Hill

Miles, George	Vyse Street.
Miller, Herbert	12, Islington Row.
Mills, Arthur E.	73, Broad Street.
Mitchell, A. B.	213, Hagley Road, Edgbaston.
†Mitchell, F. W. V. *(L)*	212, Hagley Road, Edgbaston.
†Moore, C. W. B.	King's Norton.
Moore, W. G.	Scotland Passage, High Street.
Morgan, F. J.	Board School, Moseley Road.
†Morley, J.	Sherborne Road, Balsall Heath.
Morton, E.	Wilson Road, Birchfield.
Myers, Rev. E., F.G.S. *(C)* ..	Claremont Hill, Shrewsbury.
Naden, Thomas	14, Temple Street.
Nash, F. W.	Worcester City and County Bank, Colmore Row.
Nelson, William *(L)*	Freehold Street, York Road, Leeds.
Nevill, R. A.	Richmond Road, Handsworth.
Newton, R. A.	Newhall Street.
Norris, Hill, M.D.	Walsall Road, Birchfield.
Norris, R., M.D.	Walsall Road, Birchfield.
Oliver, J. W.	271, St. Vincent Street.
Osler, Miss A.	South Bank, Harborne Road.
Owen, Lloyd	Newhall Street.
Painter, Rev. W. H. *(C)* ..	Park Hill, Knowle Road, Bristol.
Panton, G. A., F.R.S.E. ..	95, Colmore Row.
Parkes, W. E., M.D.	Soho Hill, Handsworth.
†Parsons, C. T.	Norfolk Road, Edgbaston.
Parsons, Mrs. C. T.	Norfolk Road, Edgbaston.
Parsons, Miss Mary	Norfolk Road, Edgbaston.
Parsons, Miss J. C.	Norfolk Road, Edgbaston.
Payton, Councillor H.	Eversley, Somerset Road.
Pearson, W. H.	50, Ann Street.
Pemberton, G. Arthur	21, Beaufort Road, Edgbaston.
Pendleton, W.	19, Northampton Street.
Percival, Exley *(C)*	Grassendale, Carlyle Road, Edgbaston.
Perrins, G. R.	South View, Cape Hill.
Phillips, Wm., F.L.S. *(C)* ..	Canonbury, Kingsland, Shrewsbury.
Phipson, A.	Metchley Lane, Harborne.
Pickering, J. W.	161, Belgrave Street.
†Player, J. H., F.C.S.	31, Calthorpe Road.
Player, J., F.R.G.S.	Chad House, Edgbaston.
Player, W. D.	19, Chad Road, Edgbaston.

†Pointon, A.	Temple Row.
Pope, J.	King's Norton.
Potts, J.	Bennett's Hill.
President of the Royal Microscopical Society (*C*)	King's College, London.
†Pumphrey, C. (*L*)	King's Norton.
Pumphrey, J. H...	Regent Works, Herbert Road, Small Heath.
†Rabone, J.	Penderell House, Hamstead Road.
Rabone, Mrs. J.	Penderell House, Hamstead Road.
Randall, Rev. Wm., M. A. ..	Handsworth Rectory.
*Ratcliff, Charles, F.L.S. ..	Lancaster Gate, Hyde Park.
Reading, Alf.	13, Bennett's Hill.
Reynolds, E. J.	Beaufort Road, Edgbaston.
Richardson, W. E.	59, Varna Road.
Rickards, Dr. E...	96, Newhall Street.
Roberts, T. V.	The Crescent, Murdock Road, Handsworth.
Robinson, E., M.D.	Bristol Road.
Robinson, A. E.	Milton Villa, Beech Lanes.
Robinson, C. R.	25, Legge Lane, Graham Street.
Robison, R.	Royal Insurance Co., Bennett's Hill.
†Roderick, John	Hanbury Place, Rose Hill, Handsworth.
Rooke, W...	Augusta Road, Moseley.
Rowlands, Joseph	71, Colmore Row.
Ryland, Miss Susan	46, Calthorpe Road, Edgbaston.
Ryland, W. P.	Redlands, Erdington.
†Saunders, C. H.	Robert Road, Handsworth.
Saville, G. O.	Waverley Cottage, Bournbrook.
Schwarz, Dr.	Queen's College.
Scruton, A.	The Mount, Green Hill Road, Moseley.
Sharp, Councillor	397, Bristol Road.
Sharpus, F. W. (*C*)	30, Compton Road, Highbury, London.
Shoebotham, J. H.	Highfield, Hermitage Road, Edgbaston.
Short, R. M.	Solihull.
Simcox, A.	22, Cannon Street.
Simmonds, W. H.	99, Ravenhurst Street.
Simpson, E. (*C*)	24, Grammont Rood, Peckham Road, London, S.E.
Slatter, T. J., F.G.S.	Bank, Evesham.
Slocombe, J.	Grosvenor House, Hall Road, Handsworth.
Smedley, W. T., F.R.A.S. ..	57, Colmore Row.
†Smith, G.	326, Bristol Road.

Smith, T. H.	Park Hill House, Hamstead.
Smithson, J.	Sunbreak, Wellington Road.
Southall, H. W.	Coppice Road, Moseley.
†Southall, William, F.L.S. *(P)* ..	Sir Harry's Road, Edgbaston.
Sowton, A.	Fir Tree Cottage, High Street, Harborne.
Spencer, Herbert *(Hon. V.P.)* ..	38, Queen's Gardens, Kensington.
Spencer, J.	Sandwell Villas, Birmingham Road, West Bromwich.
Spinks, W.	Royal Nurseries, Harborne Road.
Stevens, Wm.	Handsworth.
Stokes, W. H.	Helvellyn, Birchfield.
Sturge, Joseph	Wheeley's Road.
Sturge, Wilson	Frederick Road, Edgbaston.
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Tait, G. W., M.R.C.S.	Knowle.
†Tait, Lawson, F.R.C.S. *(P)* ..	7, Great Charles Street.
Tait, Mrs. Lawson	7, Great Charles Street.
Tangye, G.	Heathfield Hall, Handsworth.
Taunton, Miss F. M.	10, Yew Tree Road, Edgbaston.
Taunton, J. R. C.	116, Bristol Road.
Taylor, Reuben	Colmore Row.
Thomas, Dr. Wynne	8, Harborne Road.
Thomason, George	88, Hagley Road.
†Timmins, Sam., J.P.	Elvetham Road, Edgbaston.
Timmins, Mrs. Sam.	Elvetham Road, Edgbaston.
†Tonks, Edmund, B.C.L. *(P)* ..	Packwood Grange, Knowle.
Toon, James	Pershore Road.
Turnbull, J. R.	43, Ann Street.
Turner, John	6, Stirling Road.
Twamley, C.	Ryton-on-Dunsmore, Coventry.
Twigg, G. H.	21, Summer Hill.
Tye, G. S.	62, Villa Road, Handsworth.
Tyerman, J. *(C)*	Penley, Tregoney, Cornwall.
Udall, J.	77, Summer Hill.
Underhill, F., M.R.C.S. ..	263, Moseley Road.
Vize, Rev. J. E., M.A. *(C)* ..	Forden Vicarage, near Welshpool.
Wade, W. F., M.D.	Temple Row.
Wagstaff, E. H.	1, Waterworks Road, Edgbaston.
Walker, H. J.	Catherwell House, Stourbridge.
Waller, T. H., B.A.,B.Sc., Lond.	71, Gough Road.

Walton, F. A.	Hamstead Road.
Warden, Chas., M.D.	31, Newhall Street.
Watson, C. J.	34, Smallbrook Street.
Webb, A. J.	St. Paul's Road, Moseley.
Welch, Dr. J. B.	Medical Officer of Health for Handsworth.
Welch, Dr.	Grammar School, Stourbridge.
Wells, S. J.	Tintern House, Handsworth.
White, Councillor W.	Sir Harry's Road, Edgbaston.
Whitefoot, T., jun.	36, High Street, Bridgnorth.
Whitehouse, W.	Myrtle Villa, Broomfield, Smethwick.
Wilkins, Silvanus	Forest House, Church Road, Moseley.
Wilkinson, Captain	Elmwood, Hamstead, Handsworth.
Wilkinson, Mrs., sen.	Ariston, Hamstead Road, Handsworth.
Wilkinson, Walter	Shobnall House, Handsworth Wood.
†Wilkinson, W. H.	Great Hampton Street.
Williams, D. J.	59, New Street.
Williams, S. D., jun.	Easy Row.
Willis, W. (*C*)	49, Palace Grove, Bromley, Kent.
Willis, John	1, Calthorpe Road, Edgbaston.
Willmore, F. W.	The Willows, Walsall.
†Wills, A. W. (*P*)	Claregate, Wylde Green, Erdington.
Wills, Mrs. A. W.	Claregate, Wylde Green, Erdington.
Wills, Miss L. E.	Claregate, Wylde Green, Erdington.
†Wilson, G. E.	West Hill, Augustus Road.
Wilson, Wright, F.R.C.S. Edin., F.L.S.	21, Crescent.
Withers, F.	Rope Walk, Farm Street.
Woodfield, Dr. T. R. V. ..	Acocks Green.
Woodman, W.	Trafalgar Road, Moseley.
Woodward, C. J., B.Sc., F.G.S.	97, Harborne Road.
Wright, J. H.	Malvern Villas, Soho Hill.
Wright, Mrs. J. H.	Malvern Villas, Soho Hill.
Wright, Richard (*C*)	Holly Bank, Sale, near Manchester.
Wright, T., M.D., F.R.S. (*C*) ..	Cheltenham.
†Wynn, J. C.	Court Oak Road, Harborne.
Wynne, W. P.	Hasluck's Green, Shirley.
†Yeoman, W. C.	Park Villa, Solihull.

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AGE.		
17	Allport, Frank	Colmore Row.
16	Blatch, W. G., jun. ..	Albert Villa, Green Lane.
18	Cox, S. H.	Board School, Rea Street.
16	Dammann, J. F. R. ..	22, Francis Road.
16	Harrison, W. J., jun. ..	Golden Hillock Road.
18	Hewitt, F. E.	Woodlands Road, Smethwick.
17	Johnstone, F. W.	24, Westminster Road.
15	Matley, C. A.	49, Godwin Street, Ashted.
16	Saunders, J. V.	137, Birchfield Road.
16	Stone, H.	Cavendish House, Grosvenor Road, Handsworth.
16	Tregilgas, F. J.	3, Windsor Place, Churchill Road, Handsworth.
18	Vaughton, Vincent. ..	Ashley House, Claremont Road.
17	Wynne, A. E.	King Edward's School.

MEMBERS ELECTED SINCE JANUARY 1st, 1882.

Brain, R. T.	234, Lozells Road, Handsworth.
Derry, F., F.R.G.S.	31, Upper Hockley Street.
Gere, E. W.	Sandhurst Villa, Willes Terrace, Leamington
Greatheed, W.	Coverdale House, Hunter's Lane.
Grove, H. C.	Church Road, Harborne.
Hill, A. J., F.R.M.S.	Leamington.
Hooper, D.	98, Moseley Road.
Hughes, J.	397, Harborne Road.
Hullett, Alfred	Willenhall.
Jermyn, Miss E.	12, Islington Row.
Madison, J.	62, Camp Hill.
Mantell, C., jun.	21, Cregoe Street.
†Parsons, J.	Hall Street.
Phillips, J. T.	204, Broad Street.
Pickering, E. T.	17, Noel Road.
Sayer, H. J.	Cambridge Street.
Simpson, T.	6, Waterloo Street.
Srawley, J.	102, Westminster Road, Handsworth.
Srawley, Mrs. J.	102, Westminster Road, Handsworth.
Swayne, R. A.	Rostrevor House, Hobmore Lane, Small Heath.
Timmis, J. M.	18, Rose Hill, Lozells.
Vicars, J.	47, Hartington Road, Liverpool.
Wilkes, J. B.	Solihull.

The Treasurer in account with The Birmingham Natural History and Microscopical Society.

APPARATUS FUND.

Dr.

1881.	£ s. d.
To Subscriptions ...	13 16 6
„ Balance from General Account ...	7 0 6
	£20 17 0

Cr.

1881	£ s. d.	£ s. d.
By Apparatus, viz.–		
Cabinets ...	7 10 0	
Eye Pieces ...	1 3 0	
Objectives ...	10 10 0	
Glass Troughs ...	0 6 0	
Tubes and Sundries ...	1 8 0	
		20 17 0
		£20 17 0

GENERAL ACCOUNT.

Dr.

1881.	£ s. d.	£ s. d.
To Balance brought forward ...		19 13 1½
„ Subscriptions, 1878-79-80 ...	21 7 6	
„ „ 1881 ...	125 7 0	
„ „ 1882 ...	4 11 0	
		151 5 6
„ Cash for Bookcase sold...		10 15 0
„ Balance from Excursions in 1880-81, exclusive of Postage and Printing ...		0 17 0
„ Subscriptions received from our members for restoration of Free Library ...		11 11 0
Balance due to Treasurer ...		11 15 11
		£208 17 9½

Examined and found correct,

J. W. PICKERING, } Auditors.
JOHN EDMONDS, }

Cr.

1881.	£ s. d.	£ s. d.
By Books and Binding ...		57 15 3
„ Printing–		
Annual Reports ...	34 13 4	
For Programmes, etc. ...	7 14 3	
„ Treasurer ...	1 16 6	
„ Excursions ...	1 5 6	
„ Lectures... ...	1 7 8	
„ Midland Union ...	0 8 0	
„ Illustrations in *Naturalist* ...	1 8 0	
		48 13 3
„ Postage–		
Per Hon. Secretaries ...	20 6 0½	
„ Treasurer ...	0 18 5	
„ Excursions ...	3 0 0	
„ Soirée ...	2 3 2	
„ Sections and Librarian ...	0 3 0	
		26 10 7½
„ Stationery ...		1 5 5
„ Curator's Salary ...		28 0 0
„ „ Commission ...		5 7 3
„ Rent and Insurance ...		17 11 10
„ Subscription to Midland Union ...		4 2 3
„ Sundry Lecture and Library Expenses ...		1 0 5
„ Free Library Restoration Fund* ...		11 11 0
„ Balance of Apparatus Fund ...		7 0 6
		£208 17 9½

* Total Subscription by and through the Society to the Free Library Restoration Fund, £101 8s.

The Treasurer in account with the Furnishing Fund.

Dr.

1881.	£	s.	d.
To Subscriptions	193	18	6
,, Loan from John Morley	75	0	0
	£268	18	6

Cr.

1881.	£	s.	d.	£	s.	d.
By Marris and Norton—Furniture	249	1	0			
,, W. T. Evans— ,, ...	3	10	0			
,, J. Morley Oil Cloth	0	10	5			
,, Mr. Cossins—Architect's Commission	10	10	0			
				263	11	5
,, Printing and Postage ..				4	6	6
,, Balance in hand				1	0	7
				£268	18	6

NOTE.—Since 1861, £1,003 has been expended in Books, Apparatus, and Furniture, by the Society. Numerous valuable presents of Apparatus and Books have also been received. Subscriptions due far exceed all the outstanding liabilities on ordinary Accounts.

CHARLES PUMPHREY, Hon. Treasurer.

Birmingham Natural History and Microscopical Society.

LIST OF OFFICERS FROM 1864 TO 1882 INCLUSIVE.

*** *THE BIRMINGHAM NATURAL HISTORY ASSOCIATION was founded in* 1858, *and was reconstructed in the year* 1864, *under the present title.*

	PRESIDENT.	VICE-PRESIDENTS.	TREASURER	SECRETARY.	LIBRARIAN.	CURATORS
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1865	W. R. Hughes, F.L.S.	Thomas Fiddian L. Percival	George Heaton	James Hinds, M.B.	Thomas Scott	E. J. Chitty.
1866	W. R. Hughes, F.L.S.	Thomas Fiddian L. Percival	George Heaton	Thomas Jephcott	Thomas Scott	E. J. Chitty.
1867	Jas. Hinds, M.B.	C. T. Parsons W. P. Marshall, C.E.	George Heaton	Thomas Jephcott	Thomas Scott	Fras. Fowke.
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1869	W. P. Marshall, C.E.	William Hinds, M.D. Edward Myers, F.G.S.	George Heaton	A. W. Wills	George Crofts	James E. Bagnall.
1870	William Hinds, M.D.	Edward Myers, F.G.S. A. W. Wills	Charles Pumphrey	Edward Simpson	James E. Bagnall.	W. B. Latham. John Morley.
1871	A. W. Wills	J. W. Cotton, F.G.S. Rev. H. W. Crosskey, F.G.S.	Charles Pumphrey	W. G. Blatch	John Morley	James E. Bagnall. G. Sherriff Tye.
1872	Rev. H. W. Crosskey, F.G.S.	Jas. E. Bagnall Rev. G. Deane, D.Sc	Charles Pumphrey	W G. Blatch	John Morley	R. M. Lloyd. G. Sherriff Tye.
1873	W. R. Hughes, F.L.S.	Rev. H. W. Crosskey, F.G.S. Rev. G. Deane, D.Sc.	Charles Pumphrey	W. G. Blatch	John Morley	R. M. Lloyd. W. Nelson.
1874	Rev. G. Deane, D.Sc., F.G.S.	Edmund Tonks, B.C.L. John Morley	Charles Pumphrey	W. Wright Wilson, F.L.S.	James E. Bagnall.	J. W. Cotton, F.G.S. Thomas Fiddian.
1875	A. W. Wills	John Morley Lawson Tait	Charles Pumphrey	W. Wright Wilson, F.L.S.	James E. Bagnall.	J. W. Cotton, F.G.S G. Sherriff Tye.
1876	Lawson Tait, F.R.C.S.	Walter Graham Edmund Tonks, B.C.L.	Charles Pumphrey	C. B. Caswell John Morley	James E. Bagnall.	G. Sherriff Tye. G. Edmonds.
1877	Edmund Tonks, B.C.L.	Walter Graham G. Sherriff Tye	Charles Pumphrey	John Morley	James E. Bagnall.	John Levick. W. H. Cox.
1878	Edmund Tonks, B.C.L.	Walter Graham E. W. Badger	Charles Pumphrey	John Morley	James E. Bagnall.	John Levick. W. H. Cox.
1879	W. Graham, F.R.M.S.	E. W. Badger W. Southall, F.L.S.	Charles Pumphrey	John Morley H. E. Forrest	James E. Bagnall.	John Levick. W. H. Cox.
1880	W. Southall, F.L.S., F.R.M.S.	E. W. Badger John Levick	Charles Pumphrey	John Morley H. E. Forrest, F.R.M.S.	James E. Bagnall	W. B. Grove, B.A. R. M. Lloyd.
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1882	John Levick, F.R.M.S.	T. H. Waller, B.A., B.Sc. W. G. Blatch	Charles Pumphrey	John Morley W. B. Grove, B.A.	James E. Bagnall.	R. M. Lloyd. H. Miller.

ON A NEST-BUILDING FISH.

THE STICKLEBACK (*GASTEROSTEUS.*)

BY SILVANUS WILKINS.

Read before the Society, April 12, 1881.

That a fish could build a nest has been very much doubted, and even now when believed the fact is supposed to be very rare. In truth it is common enough, and as it can be made familiar, so to say, at our own doors, I have thought the subject would not be out of place in a magazine published in Birmingham. The strange part is, that the entire work of preparing the nest, hatching out, fostering and rearing the young, is done by the MALE.

The whole process of fish nest-building, by, literally, the hundred, can always be seen from April to July, in the ponds about the "Black Country." The simplest appliances will serve. There is nothing difficult in setting about observing the method of it, either out of doors or in your own homes. Take the train, say—to Bilston—ask for the Theatre in the Willenhall Road, and from the back of it strike into any of the paths across the pit mounds, in a northerly direction, towards Portobello. Before going a thousand yards you will come upon several ponds of various sizes, almost any one of which will do if you go the right way to work.

There are, however, two or three near together, known as Edward's Pools, or "pewls," as the lads there call them, that are very good. I mention these, being easily found by name, but there are many others in the hollows off the main paths that are even better for quiet observation.

On coming to a pool saunter very slowly, casting your glance into the water about two or three yards ahead of you, near the side, where the water may be from six to twelve inches deep. A very little practice will enable you to see a fish of a brightish green colour quickly turn away from the shallow into deeper water out of sight as you approach. This is the male stickleback of our ponds, and you may now know you have "spotted" a home or nest, though, for a moment, you don't see it. Having marked the place in your eye where the fish sank out of sight, advance slowly directly opposite to the spot, and sit down on the bank about a yard away from the water, and do not move. In a very short time—a few minutes at the most—you will see my gentleman fish rise from the deeps, end on towards you; a "green-eyed monster of jealousy" of most brilliantly metallic hues. This is the courtship dress with which he has during the preceding few weeks clothed himself. What change of food or chemistry of life must have gone on during this period to deposit on his coat so rich a change of colour, beating all Elkington's electro-work, is, I opine, yet a mystery.

You are now over the chosen spot where the fish has made up his mind to squat or pitch his tent. Continue to remain quite still and he ignores you, and resumes work according to the stage it has reached. They begin to select a spot according to the warmth of the spring weather, about April; and by June one may be found settled in almost every square yard along the shallows.

You will first notice that he does not roam at large, but moves about in a radius only of four or five feet. If in the early stage, he will be constantly returning with a piece of water-weed, an inch or so long, in his mouth, like a bird with material to its nest, until the nest is formed. When finished, it is about the size of half a walnut, only much less convex, and is disguised by the water-weed and particles of the soil placed about it. If the bottom of the pool is small gravel, ash, or such like, he places the same material about to hide it, or if of the nature of sand or mud, he sucks some of these up in his mouth and puffs them out, like a smoker, about the surface of the nest with the same purpose, and perhaps to weight down the lighter materials.

Having placed something on the bank to indicate his whereabout, you may always be sure to find him there at work for a few weeks until he has reared to maturity the entire brood. I indicate the spot with two stones, or bits of tile, as marks, treading one into the path the same distance from the edge of the water that the nest is in the water, and another further off in a right line with it. The starting of the process goes on all through April, May, June, and I have seen it in July, so that by land-marking opposite several nests you may see all the several stages, of a dozen if you like, going on at the same time.

If the nest is finished and charged with eggs, you may readily find it on the bottom of the pool by noticing a small hole about the size of a pea, with the lines of the weed-structure all leading to a centre, giving it the appearance of a small sphincter, pursed up like a mouth in a pucker, and that he is frequently poised over this opening inclined head downwards in the attitude of a good diver just entering the water, vibrating his fins to move the water towards and into the nest. This action may also be seen, with a bull's-eye lantern, going on at night.

Each fish has his own home and family, and protects them against all the world—that is to say, his fish world. This can be shown by catching one and marking him with a small loop of bright-coloured floss silk as a signal, which you draw just "taut"—not tight—over the narrow part of the body, leaving a small pennon to trail out about a quarter of an inch or so beyond his tail, by which to identify him, and then carrying him in a vessel some fifty yards away to another part of the pool, when in a short time, according to the distance, you will find him, like a homer pigeon, returned to his nest, having been chased and driven on, like a runaway dog, by many of the others as he passed over or near their territory. You can often keep him in view the whole way back. On these occasions he rarely stays to fight much except to make passage.

As soon as the home is ready he waits near, trimming it with his snout, until a lady visitor of a sad green shade, but withal sublimely portly, approaches. Then his vivacity is increased. He shoots back dodging round her, and gets her between himself and the nest, pushing and bunting at her with his lip, down towards an opening he has left at the base of the nest, through which she glides into it. While there he seems in a quiver of delight, but presently he butts at the opening she enters by, where her tail may be seen protruding, and startles her out, lightened, through generally the other side, where a similar opening appears to be left. This seems to be the whole of the lady's direct responsibilities and duties. I say seems so, but it is conceivable that if we could divine her ruminations she might possibly be claiming for her work that it was more vital and honourable than her mate's, and that his work was but the materialistic.

The two openings at the base he now proceeds to close with weeds and by dragging the fibres of the nest together, leaving only the small hole at the top open, over which he diligently works at the vibratory action. This is now varied frequently at intervals of a few minutes by his curving his body round about and over the nest, first in one direction, then the reverse, suggesting the action of a cat pushing against one's legs when purring. The hatching is evidently helped by the sun striking into the shallow water, as I have noticed that the time is always retarded by a few days in chilly weather. I have never observed them building in water much over two feet deep. Sometimes they build very near the edge, and in very hot weather, as the pool lowers by evaporation, the nest becomes exposed. The pertinacity then with which they will continue fanning as the water recedes, with their bodies half out of the water, just turning back for a time for breath as it were, is, I may say, painful to see.

A good strong nest contains about a teaspoonful—from 200 or so of eggs—each about the size of a mustard seed. By the time—about fourteen days in hot weather—when they begin to hatch out, the flow of the water, caused by the fanning, seems to loosen the texture of the nest, and as the young emerge from the egg the anxiety of the mid-husband (I can't call him mid-wife) begins, and his watchfulness and attention increase until it reminds one of a panting colley dog on the skirts of a flock of sheep keeping them together. As they escape from the shell, he sucks or gulps the shell into his mouth, as he does other waste materials, carries it a few inches and blows it out to float away.

The young fry at first keep well together, circling about in the opening of the nest, but as they grow stronger they venture into the water around, where they are liable to be snapped up by the full grown of their own kind who are passing near. Now it is amusing to watch the extra industry and affection with which the male nurse will dart after the vagrants. He cannot well carry them as a cat does a stray kitten by the back of the neck, but as one may float out and away he follows it and it disappears, having been simply sucked into his mouth. While wondering what has become of the straggler, you notice he turns about, advances to the opening, and puffs or projects it, head over tail, back into the nest, more deftly, indeed, than Zazel is projected out of the monster gun in her Aquarium. You see she is well matched here, and not even original. This goes on constantly until he can see that each one can poise or hold itself in the water.

It is comical to see one of the fishlings with half of the body out of its shell, sometimes the head only, sometimes the tail, making wobbling attempts at swimming, and sometimes head and tail out, but with the shell round the middle of the body, like "Johnny Stout" in the pantomime. This finer work may partly be seen in a pool by slipping a white shallow saucer, palette, or an oyster-shell or two, white side up, on the ground, close to the edge of the nest, when the young fry will show out in dark streaks over it, like a shoal of notes of admiration, which certainly they are. Now you may test the bravery of the parent, for if you pass a stick down amongst the young he will not be forced away, but often will strike at it hard enough for the blow to be felt by the hand.

The work of the nest building can be watched very well in the pools, but for rearing the young more can be done and observed in the aquarium. A trial or two in rearing generally proves successful. I will assume that the aquarium is prepared in the usual way with balanced vegetation, &c. It should have a bed of neat gravel, and some bits of clinker or stone with a slight hollow in one piece, well placed, to lay the nest in. The water should not be colder than that of the pool.

One way is to catch a gentleman fish about May and turn him into the aquarium. If he builds and prepares a nest you then introduce, one alone at a time to prevent jealousy, his lady-loves, some six or so, and wait the course of events; but the better plan I think is this: Watch a few nests in the pool until you find one strong and full, over which the hatching has just begun, shown by his ceasing the constructing work, and beginning at the vibratory motion or fanning. Have ready a net, made of fine brown or dark green silk, about a quarter inch mesh (such as girls use to net their back hair in), sewn round a ring of about nine inches diameter. Get a small worm (a blood worm is the best, found here in the mud of the ditches) for a bait, without hook, tie to the end of a line of fine silk fastened to a stick. Lower the worm gently over the nest. At first he may retreat, but will soon return and gorge it far enough into his throat for you to raise him out into your net, slipped under him held in your left hand. Turn him out quickly into a jar, as large a one as your false pride will allow you to carry. They appear less excited and alarmed in this than in a glass bottle, and a new one is best for fear of taint of acids or sweets. If you haven't a worm, and will work very slowly, you can generally move this kind of net towards him, pass it under him, and lift him out into your jar, but they will shy and keep backing away from a white muslin net. Catching with the sort of net I mention is best, as I am not quite certain that disgorging the worm may not give the fish a sore throat. Having got the parent, you then reach out to his nest and carefully pass your two fingers under it into the soil to which it is very slightly attached, and raise it up with the eggs as little disturbed as you can, placing it with some water in a shallow vessel—it carries best so. I used a cold-cream pot, well cleaned, about three inches wide and an inch deep, covering it with the lid or a skin, held by an elastic band, to carry the nest home in.

The aquarium should be placed where the water receives a fair amount of sun, but will not get too warm, and the nest should either be turned away from where it can be seen, except by a side view—or, better still, from behind some kind of screen with a hole in it ; or you may colour one side of the aquari m with some opaque green colour, leaving a small space clear through which to watch him at work. This is almost necessary, for if they see they are overlooked, they, like some other animals, are apt to devour their own offspring, hatching them out merely to swallow them as tit-bits. Feeding him with a small worm every few days helps to check his voracity.

In placing the nest in position, arrange it to lie in the hollow of the clinker or stone, about the same depth at which you found it in the water, as much like its proper form as you can, keeping the eggs under the conferva-framework of the nest, as little exposed as possible. This, however, does not so much matter, as the bold fellow, when you introduce him to the water, after swimming about for a time, as soon as he finds the dwelling with its future family, will set to work at once to put it in order. This is very interesting. To help him to do this, a little of the conferva from the same pool should be added for materials. We are told the name of this "genus" is Gasterosteus, meaning spine-belly, presumably, I suppose scientifically, because its spines are chiefly on its back.

All the fresh-water species described, some six, are to be found in this locality, but there is one I have not seen specially distinguished anywhere. This is a fellow nearly black, which certainly I would suggest ought, from his surroundings, to be called the "collier."

I have limited the paper to a few practical notes, helping, I hope, to the history proper of this strange little fish. I shall be glad if it induces any unpractised naturalists to observe and picture more fully his wonderful gifts and display of moods, affections, and sentiments, so much like our own.

There are many pools here undisturbed for years by cattle foot or banking up that are very rich in other pond life, but the Mines Drainage Commissioners are rapidly altering the face of parts.

Max Müller, in his "Manners and Customs," describes the practice of the Basques, that in Biscay the women rise immediately after child-birth, while the husband goes to bed, taking the baby with him; and he mentions how Mr. Tylor, in his researches into the development of civilisation, seems to despair of the existence of any custom anywhere which cannot be matched somewhere else, and he asks, is this a natural custom? Well, certainly, we have it well matched here, and may say it is a custom entirely natural to some fish. If man is a microcosm of nature, the complete counterpart or prototype of the practice is certainly found in the stickleback of our ponds.

If this mid-husbandry was the practice in the early history of mankind as he states, and it be probable, as we sometimes hear, that mankind will revert, in the second childhood of the race, to like ways, there may be some comfort to the strong-minded of the other sex in the prospect that ultimately the males of the future must return to the duties of the nursery.

Plate I.

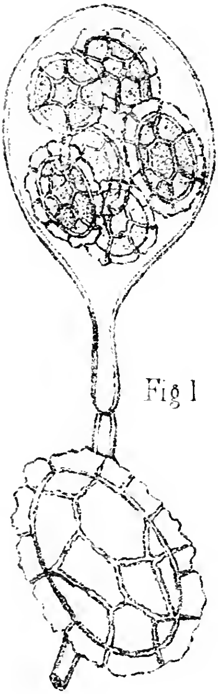


Fig 1

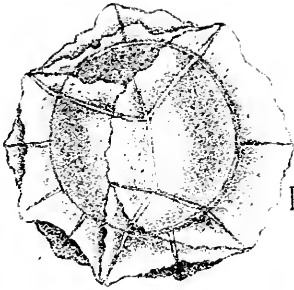
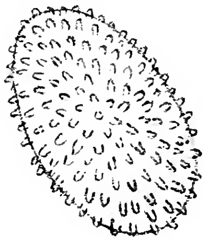


Fig 2.



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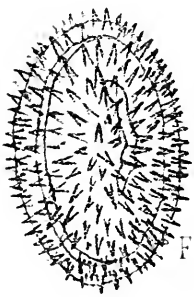


Fig. 3.

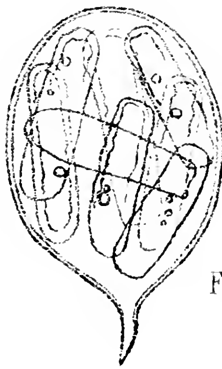
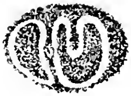


Fig. 5.

UNDERGROUND FUNGI.

Plate II.



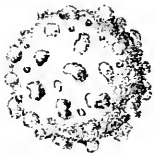


Fig. 7.

Fig. 6.

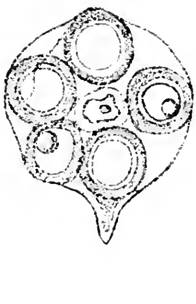


Fig. 8.

UNDERGROUND FUNGI.

Plate III.

Fig.10.

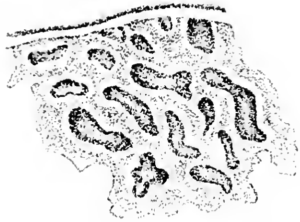


Fig.11.

Fig.12

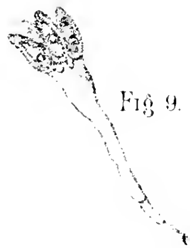


Fig 9.

Fig 13

Fig 14

Fig.15

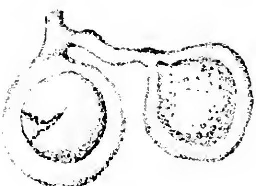


Fig.16.

UNDERGROUND FUNGI.

W B G L.

ON UNDERGROUND FUNGI (FUNGI HYPOGÆI.)

BY THE REV. M. J. BERKELEY, M.A., F.R.S.

Read before the Society, October 4th, 1881.

The most interesting objects in Natural History are often found amongst the most anomalous forms. This is peculiarly the case with the particular group of Fungi which I have chosen for the subject of the present paper, in which I do not profess to make any new observations, but I shall be quite content, should it prove to your members at once interesting and instructive. I should be more able to make it so if I could address you *viva voce*, with power of continual illustration by means of figures drawn at once in your presence, but at my advanced age, now verging on eighty, it would be impossible for me, and I must not attempt that in which I might possibly break down; and I now comply with the request which has been made to me, as far as my powers allow.

The Fungi in question are those which are, as a rule, produced beneath the surface of the earth, or which after a time become superficial. They belong to several different types; they abound in calcareous districts, to which many species are restricted, and only a few species can be expected to reward the researches of your local Naturalists. In favourable localities, as the neighbourhood of Bath and Rockingham Forest, many species are abundant. Wiltshire and Kent, and other chalk counties, produce the greater part of what are sold in Covent Garden, but, if properly hunted for, there are parts of Northamptonshire which could yield, as I know by experience, an

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REFERENCES TO PLATES I., II., AND III.

Fig. 1. *Tuber æstivum*, Vittadini, ascus with sporidia and single sporidium.
2. *Tuber Borchii*, Vittadini, single sporidium.
3. *Tuber nitidum*, Vittadini, single sporidium.
4. *Tuber rufum*, Pico, single sporidium.
5. *Balsamia vulgaris*, Vittadini, ascus with contained sporidia.
6. *Genea verrucosa*, Vittadini, section of plant slightly enlarged, and section highly magnified, shewing the linear ascus with its contained sporidia.
7. *Genea Klotschii*, Corda, section of plant natural size, and single sporidium.
8. *Elaphomyces Leveillei*, Tulasne, ascus with the contained sporidia and single sporidium.
9. *Melanogaster ambiguus*, Tulasne, sporophore with spores.
10. *Hysterangium nephriticum*, section shewing sporophores and spores.
11. *Rhizopogon rubescens*, Tulasne, section magnified.
12. *Hymenogaster citrinus*, Vittadini, sporophores with spores.
13. *Do.* *do.* surrounded by cyst.
14. *Hymenogaster Thwaitesii*, Berk. and Broome, spores with cyst.
15. *Endogone pisiformis*, Lk., section of plant slightly magnified.
16. *Do.* *do.* Threads with cysts.

All the figures are copied either from Corda or Tulasne, but the correctness of all has been verified. They are all more or less highly magnified, except where it is otherwise stated.

abundant supply. They, however, in general require a good deal of diligence in research, and some tact in selecting the most fertile spots. It was at one time doubted whether a single species were indigenous. But in "Morton's History of Northamptonshire," published at the beginning of the last century, Rushton Wilderness, formerly in possession of the Tresham family (too well known in history), is mentioned as producing them, yet even then it was doubted whether they had not been introduced with exotic shrubs; but now more than forty species have been found near Bath, and half that number in Northamptonshire. As Truffles are always valuable in the London market, though we do not possess the two species which are most esteemed abroad, one of which is found, indeed, only in Italy, a successful hunt would amply repay the labour of research, and it becomes matter of interest to ascertain means by which they may be found without waste of time and labour. In a particular parish in Northamptonshire they were once so abundant that in a few minutes I could collect as many pounds weight of truffles, some of them of extraordinary size, but this is only the case in favoured spots. The more common way is to train dogs for the purpose, which they answer most effectively. In Germany, pigs are sometimes employed, and there have been cases in which idiots, who could be employed to no other useful purpose, have been found to be first-rate truffle-hunters. The dogs belong to a peculiar breed, between a poodle and a turnspit, and by hereditary descent acquire an especial faculty. They have been trained to such a nicety that Vittadini, who made truffles an especial study, and published an excellent work on the subject, and, indeed, was one of the first to call attention to their real structure, if he wished to get additional specimens of any particular species, had merely to show a specimen to his dogs, allowing them to sniff the peculiar odour, and they would go off into the woods and bring back that species, and that alone. Truffles in that country are a great source of gain to poachers, who send their dogs into the proper localities, who hunt without making the slightest noise, and soon reward their contraband masters. The mode of training is very simple. A truffle is placed within a hollow ball, which is perforated in every direction, and given as a plaything from the earliest age, the dogs thus becoming completely familiar with the scent, which is peculiar, and, as this is very penetrative, they readily detect the spot beneath which a truffle is concealed. But in this country in general the dogs are not so completely trained as to be trusted alone, for they are very fond of the truffles, which they would at once devour. But to prevent this the truffle-hunter carries biscuits, or something which the dog likes better than truffles, and while a portion is thrown down the specimen is secured.

Truffles, as said before, are produced principally in districts which abound in lime. Many attempts have been made at their cultivation, and it was once confidently announced that, like mushroom spawn, truffle spawn would in a few months be on sale. But it ended in utter disappointment. Still, after this result, the late Mr. Disney, of the Hyde, near Ingatestone, made experiments in this direction, and he was so confident of success that I was invited to witness the result of his experiment, the failure of which might indeed have been anticipated, when it appeared that his experimental specimens of truffles were obtained from the Italian warehouses, consisting of refuse slices of truffles, dried by artificial heat. In one case alone something like germination seemed to have taken place. Experiments more rationally conducted were made at the Horticultural Gardens at Chiswick, but the truffles merely rotted without anything like germination. The result was so unsatisfactory that the experiments were not renewed. Better attempts were made by others in more favourable quarters. In the south of France the Viscomte Noé, who was once well known in this country as an emigré, raised truffles in some abundance by enclosing a tract of ground in the forest to keep off the wild boars, which would at once have devoured everything. The ground was then well watered with fluid in which fresh truffles had been grated, and thus he obtained a supply; but this could scarcely be called cultivation. Another plan is adopted with great success in Poitou, which yields the best truffles of Paris. A tract of ground is selected on the downs, and when properly enclosed is sown with acorns, and in a few years, when the seedlings are well established, there is always an abundant supply which continues for several years, when it generally ceases. It was supposed that the young truffles were parasitic on the rootlets of the seedling oaks, but this has not been proved; and in many countries they are by no means confined to oaks, indeed, are most abundant when there is an admixture of beech, hazel, and even of conifers. Their site is sometimes easily detected by the presence of an insect belonging to the genus Leiodes, which hovers about them with the view of depositing its eggs in a favourable situation for their introduction into the fungus, and thousands of specimens are in this way destroyed by the larvæ of the beetle.

It is time, however, that I should say something of underground Fungi in a scientific point of view.

It is well known to every one who has paid the least attention to the structure of Fungi and their classification that there are two great types, namely, those which produce their reproductive bodies (spores) on the tips of certain privileged cells called sporophores or basidia, and those which are developed *within* certain organisms which are called asci or sacs. The former is considered in general the higher division, including the large tribe of mushrooms, and their numerous close allies for which we have no general popular name, though most of us know that of the puffballs, and our smell informs us too unpleasantly of the presence or neighbourhood of the stinkhorns, a few, however, of which, especially of exotic species, are extremely beautiful objects. As regards the other branch we have the cup-shaped Fungi, known under the name of Pezizas, some of which attract notice by their splendid colour.

There is a third group to which we shall have to advert presently. As, however, the true truffles of commerce are the objects of most importance in an economical point of view, I shall advert to these first.

The common Truffle, whether under that name we include the French Truffle* (*Tuber melanosporum*), the black-seeded Truffle, or our own most abundant species *Tuber æstivum*, the summer Truffle, presents when divided vertically a number of pallid veins which communicate with the warty surface of a dark brown or black tint, and consist of branched threads, which answer to the hymenium (fructifying surface) of the cup-fungi, as they give rise to the fertile threads which are terminated by the seed-sacs. A common lens is sufficient to indicate their presence, where they appear as dark specks. The further investigation requires a compound microscope, and few objects are more interesting than the enclosed sporidia, of some of the more marked of which I have submitted figures to the meeting. They are in general of a comparatively large size, and their external surface is variously spinulose, warty, or reticulated, often to an extent which does not take place in more aerial Fungi. In a few cases, however, as in *Balsamia*, they are smaller and quite even. Very little is known about the impregnation of Fungi, but in the true Truffles, as in some species of the cup-fungi and the water-fungi, which are the destruction of fish, and especially of young salmon, certain threads swell at the tips and curl round the sacs, to which they impart the male element, the whole process in Truffles being completed beneath the surface of the earth. Spermatozoids or spermatia have not been discovered in these Fungi.

Several species have been found in this country, each of which is distinguished by its own peculiar odour; but most of these are so small that they are at once thrown aside by the collectors. The odour of *Tuber melanosporum* is so penetrating that it cannot escape the prying nose of the exciseman or douanier, however cunningly it may be concealed.

There is, however, a distinct genus *Choiromyces*, known amongst other peculiarities by its pale colour and even surface and globose sporidia, which is esculent, though far inferior to the summer Truffle. The species sometimes grow to a large size, and are met with unexpectedly in the most unlikely spots, but occur occasionally in great profusion, principally in avenues of oaks. We are not aware, however, that they ever appear in our markets, and when fresh they are rather acrid. Either the same genus, or one closely allied, produces in Africa and near Damascus abundance of esculent Fungi, of which I have received a large bag of dried specimens, which proved when cooked perfectly insipid. They occur principally about the roots of several species of Cistus, and are found again in the Canaries. They are quite worthless as far as aroma is concerned. The *Choiromyces*, or white Truffles, have long

* We believe that the truffle collectors at Audley End call young *Tuber æstivum* before the seed-sacs are formed by that name.

been known in this country, and are figured by Sowerby. A small Truffle, belonging to the genus *Balsamia*, distinguished by its small oblong, smooth sporidia, is often rooted up by squirrels under beech trees, the odour, as the name implies, betraying its presence.

One of the most curious and instructive genera, as throwing much light on the structure of Truffles, is that of *Genea*, of which we have more than one species in this country. It is, in fact, a Truffle unravelled, as it were, or turned inside out, so as to expose every one of the veins, so that each has a distinct peridium, the whole having one general aperture, instead of all the veins being enclosed within a single crust. It is foreshadowed, perhaps, by those species of Peziza which are more or less subterraneous in their mode of growth, as *P. geaster*, &c. It is, however, to be remembered that the sporidia have no longer the same hyaline appearance, while the structure of the outer coat resembles that of *Tuber*. In the genus *Sphærosoma*, there is no peridium, and the structure is as near that of Peziza as is conceivable, the hymenium being merely undulated or tuberculated. I might advert to other genera of which we have examples, and of some of which no British species has as yet been discovered, especially that of *Picoa* which will some day reward researches among bushes of Juniper. *Hydnotrya*, like *Sphærosoma*, is entirely without peridium. The genus *Elaphomyces* approaches some of the Puffballs, but has asci, and the sporidia, which are perfectly globose, have more than the two usual integuments. The genus *Scleroderma*, however, which is a true Puffball, is sometimes quite hypogæous in its mode of growth, especially where the soil is sandy; and in some parts of Belgium or the United Provinces, where it is very abundant, it is used when young as a substitute for Truffles, of which it is a sorry representative. It is said it is used especially for the Strasburg terrines. It will, however, be more interesting to proceed to others which are more distantly related in structure to the Puffballs, but in which the veins are not resolved into a mass of threads mixed with the dusty spores. One of these, belonging to the genus *Melanogaster*, is well known at Bath as the red Truffle, but though so far culinary as to be employed to give a dark colour to the sauce of a salmi, it is quite free from any pleasant aroma, and if largely used it is very doubtful whether it is quite wholesome. When fresh, the odour is powerful enough, and in an allied species which occurs sometimes in company with the summer Truffle, the smell is quite overpowering, and approaches that of assafœtida. It was known originally as the Musk Truffle.

The species belonging to the second division, distinguished by the spores being naked and numerous, but most of them of small size, are merely of botanical interest, and may be distinguished as *false Truffles*. *Melanogaster* and *Rhizopogon* are distinguished by the peridium being traversed by creeping branched fibres. The spores in the former are dark, in the latter hyaline. Though a species of *Rhizopogon* sometimes occurs abundantly in sandy soils, its odour in age becomes stercorous, and, perhaps in consequence, no one ventures upon it as an esculent. Many species of the genus *Hymenogaster*, which is without the creeping filaments, occur in this country, but most of them are small, and the larger species are by no means tempting. It is curious that in one or two species the spores, though really terminal, are found occasionally surrounded by a cyst, anticipating a structure which obtains in certain moulds. *Octaviana* and *Hydnangium* have sometimes rough, sometimes smooth, spores. One of the latter is remarkable for its orange colour and its almost superficial growth, as I have seen it in the neighbourhood of Bristol. As if no type was to be without its representative, we have the genus *Hysterangium* whose white cartilaginous peridium separates entirely from the fructifying substance, which resembles in colour that of a *Phallus*, and is inclined in age to become soft, though it does not run away, as in *Phalloideæ*, into a loathsome mass.

Those species of *Hymenogaster* which produce a cyst round the spores lead us to the genus *Endogone*, in which, and in its exotic ally, we have essentially a subterraneous *Mucor*. It would scarcely be interesting to go into further details. The drawings submitted to the meeting will shew the peculiarities of structure. We may remark, in conclusion, that, as at present known, we have twenty-six species of Truffles, nineteen of false Truffles, and two of Endogone.

Besides these, Tulasne has figured subterranean forms of a few Fungi, which have generally äerial growth. One or two of these, as the Saffron Fungus, which is so destructive to the Saffron Crocus and the Copper Web, which destroys Asparagus, Lucerne, and Mint, are too well known; but perfect fruit has at present not been detected in these species. Still less has it been found in the large Cocoa Nut Fungus, known under the name of Tuckahoo in the United States, which is really an altered state of certain roots, the whole substance being converted into pectic acid, and is used like that for jelly. The equally large masses called in Australia Native Bread, belonging to the genus *Mylitta*, have not been found with perfect fruit, but as far as it is at present known it belongs to the real Truffles. It is highly nutritious, and when dry so hard that it requires to be grated, and answers the purpose of Sago. In Italy large globular masses of earth impregnated with spawn are known under the name of Pietra Fungaya, and when moistened yield an esculent species of Polyporus. Specimens of the perfect Fungus were produced in this country at the Hammersmith Nursery in the last century, by the ancestor of the present firm.

I know of no tribe of Fungi which exhibits more various forms, or more natural genera. Many species probably might reward future researches in this country; but the search for Hypogæous Fungi is so laborious, and it may be added so exclusive, when carried on perseveringly, as it was by Messrs. Broome and Thwaites, that they are not likely to be very numerous. *Octaviana compacta* is, perhaps, the most recent addition to our list.

ON THE DESMIDIEÆ OF NORTH WALES.

Read before the Society, May 10th, 1881.

During the unusually hot month of August of last year, I spent several weeks at Capel Curig, making that place my centre, and taking daily rambles in the neighbourhood extending to Beddgelert, Ffestiniog, the Ogwen Valley, and to every peak and ridge in the ranges of Snowdon, the Carnedds and the Glyders; and, of course, to the intervening valleys, with their streams and bogs, and to the wild moorlands in which the district abounds. These latter are the especial haunts of those beautiful plants, the Desmidieæ, but the long drought which prevailed at that time had dried up most of the pools and boggy places in which they are to be chiefly sought, and, on the whole, my gatherings were disappointingly few in number and unproductive in kind, although here and there some rare species was found. During these rambles, I had many times passed and re-passed the little foot bridge which spans the river issuing from Capel Curig lakes and leads across into the wooded slopes of Moel Siabod, and had often lingered to watch the sportive movements of the shoals of small fish which were constantly gambolling in the sun. On the last day of my stay, I was enjoying the *dolce far niente* at this spot, and regretting mentally that next morning would see me with my neck in the accustomed collar, when my eye rested on certain small bright green spheres among the weeds below, and I immediately fetched a bottle and bore some of them off to my lodgings for cursory examination. They proved to be masses of the well-known Infusorian, *Ophrydium versatile*, but attached to or embedded in these were several Desmidieæ new to me, and on examining fragments of the weeds which accompanied the Ophrydium, I found that these were the nidus of still larger numbers of the Desmids. I had only time to run down to the lake with two or three bottles, and to cram these with myriophyll and other water weeds, and to take my departure from these happy hunting grounds by the inevitable coach.

On my arrival at home, this material was well washed out in a basin of water, and the resulting sediment transferred to several large bottles, and for some days frequent changes of water made, so as to get rid of the bulk of the slimy unstable vegetable matter which abounded. There remained a flucculent brown deposit at the bottom of each vessel, very rich in Desmidieæ, and affording ample scope for many evenings' work. This material proved extremely rich in those elegant, but very puzzling plants, the Staurastra. A considerable number of species, both of this and of other genera, are hitherto unrecorded in England; others have not been detected in any part of Great Britain, while several appear to be hitherto unknown.

I have here gratefully to acknowledge the great kindness of Dr. M. C. Cooke, to whom I have submitted either specimens or drawings of the whole of these new or rare species, and who has not only given me the benefit of his large knowledge of this family of plants, but has taken the trouble to examine a large number of the original specimens of Nordstedt, Wittrock, and other Continental botanists, in order to ensure accuracy in the process of identification, and to avoid the possibility of describing as a new species some organism which may have been already recognised as belonging to either the European or extra-European flora.

I would here also say a few words as to the paramount importance of recording with accuracy the dimensions of microscopic objects, and of delineating those of any particular class to some uniform and convenient scale.

Many works on the subject of fresh-water Algæ lose much of their value from defective records of these particulars, and even the admirable essay of Ralfs on the British Desmidieæ is blemished by the want of uniformity of scale in the beautiful drawings which illustrate it; hence a tedious process of calculation from the actual dimensions is necessary before a just comparison can be instituted between these several figures, or between these and any specimens under observation.

A convenient amplification in sketching the Desmidieæ is that of 400 diameters, and by operating on some object of known size it is easy to ascertain, once for all, by what arrangement of the microscope, its objectives and eyepieces, this amplification is obtained in the apparent image formed by the camera lucida, or neutral tint reflector. Thus, with my Ross microscope, the tube being placed nearly horizontally, (10⅜ inches from bottom of eyepiece to surface of paper,) ¼ inch objective and B eyepieces give an image of an object placed on the stage which is magnified by 400 diameters. A corresponding scale representing 1-10th of a millimetre divided into ten parts, each therefore = ·01 mm., being applied to any drawing made in this manner, the actual dimensions of the object which it represents are read off at once.

The unit ·001 mm., is recognised by Continental botanists under the symbol μ, and the dimensions of the Desmidieæ are recorded in the following manner:—*e.g.*, "Long. = 21 μ; Lat. = 20 — 21 μ; Lat. isthmi = 5 μ." It is only in this country that the barbarous notation of inches and their decimal parts still lingers.

This scale is adopted by Dr. Cooke in the measurement of sporidia and other microscopic organisms to which an equal amplification is conveniently applied. The value of a uniform system of this kind is self-evident. It enables correspondents at once to institute a just comparison between their specimens without a laborious process of calculation; and it is much to be desired that some such arrangement, based on the metrical system, should be universally adopted in the descriptions and illustrations of microscopic organisms contained in scientific works, and in the transactions of all societies devoted to the study and investigation of such subjects. I should rejoice to see the Midland Union of Natural History Societies, and its excellent medium "The Midland Naturalist," taking the lead in the introduction of this simple but important reform.

The following list of Desmidieæ comprises those found in the neighbourhood of Capel Curig during the month of August, 1880, to which are added some few taken during previous visits to North Wales.

It necessarily includes the common as well as the rare species. Those which have not hitherto been recorded from English habitats, but which have been detected in Ireland or Scotland, are indicated by an asterisk; those which have not been hitherto discovered in the United Kingdom, but which are known as European, American, or Arctic species, by two asterisks.

Abbreviations.

Bréb., De Brébisson.
Ehr., Ehrenberg.
Hass., Hassall.
Kütz., Kützing.
Lund., Lundell.
Menegh., Meneghini.
Näg., Nägeli.
Nords., Nordstedt.
Wittr., Wittrock.

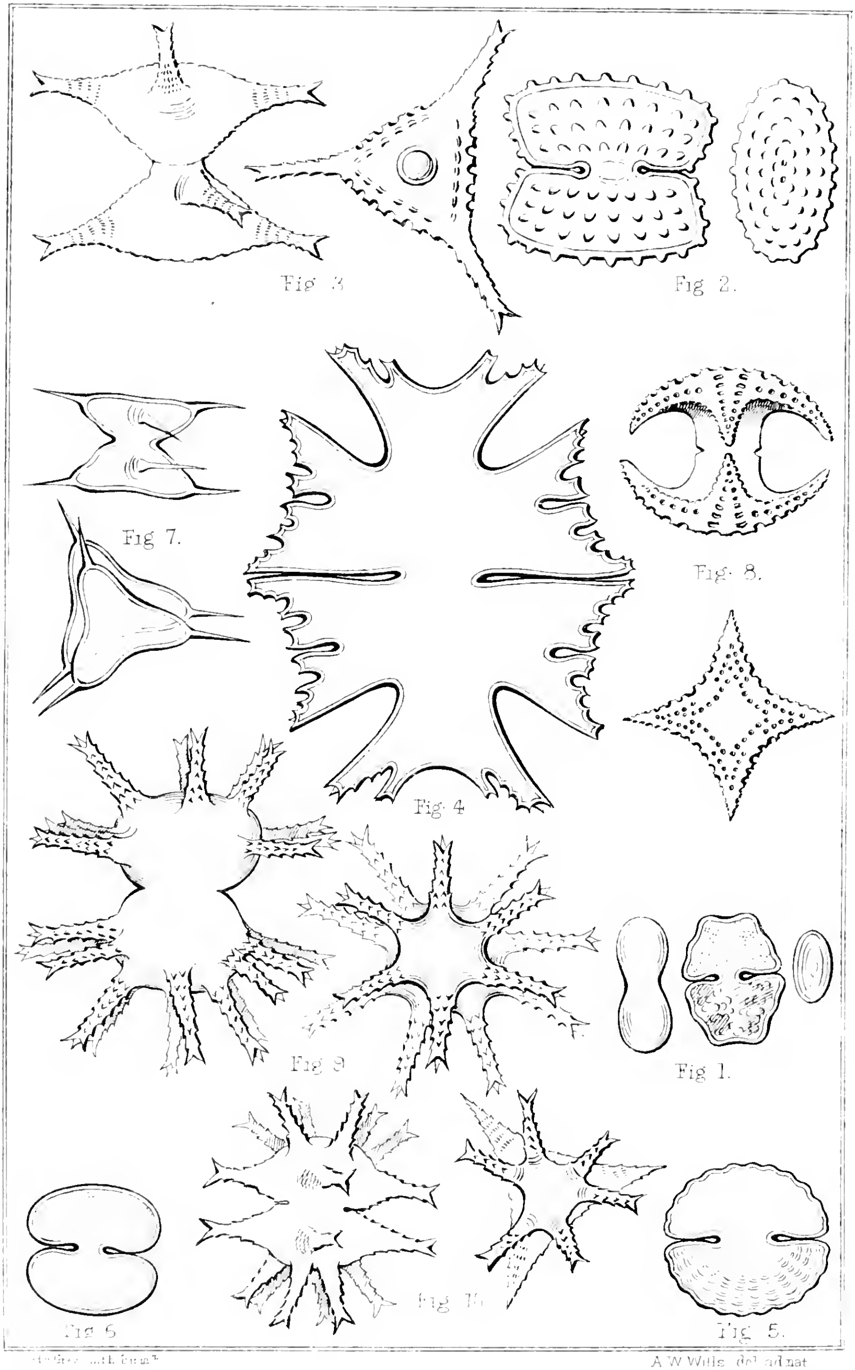
*Gonatozygon Brébissonii, De Bary.
Ralfsii, De Bary.
Hyalotheca dissiliens, Bréb.
mucosa, Ehr.
Didymoprium Borreri, Ralfs.
Grevillei, Kütz.
Desmidium aptogonum, Bréb.
Swartzii, Agardh.
Sphærozosma excavatum, Ralfs.
vertebratum, Ralfs.
*Spondylosium pulchellum, Archer.
*Tetrachastrum mucronatum, Dixon.
oscitans, Hass.
pinnatifidum, Kütz.
*Micrasterias angulosa, Hantsch.
Americana.
** ,, forma major, Reinsch.
crenata, Bréb.
denticulata, Bréb.
fimbriata, Ralfs.
furcata, Agardh.
Jenneri, Ralfs.
papillifera, Bréb.
radiosa, Agardh.
rotata, Ralfs.
truncata, Bréb.
Euastrum affine, Ralfs.
ampullaceum, Ralfs.
ansatum, Ehr.
binale, Ralfs.
* ,, var. angustatum, Wittr.
Euastrum crassum, Kütz.
cuneatum, Jenner.
Didelta, Ralfs.
elegans, Bréb.
gemmatum, Bréb.
insigne, Hass.
oblongum, Ralfs.
pectinatum, Bréb.
verrucosum, Ehr.
Cosmarium bioculatum, Bréb.
biretum, Bréb.
Botrytis, Menegh.
Brébissonii, Menegh.
cœlatum, Ralfs.
connatum, Bréb.
conspersum, Ralfs.
crenatum, Ralfs.
Cucumis, Corda.
Cucurbita, Bréb.
*cyclicum, Lund.
cylindricum, Ralfs.
granatum, Bréb.
*Holmiense, Lund
** ,, var.
**læve, Nordst. and Wittr.
margaritiferum, Menegh.
Meneghinii, Bréb.
moniliforme, Ralfs.
**nitidulum, de Notaris.
*Nymannianum, Grunow
orbiculatum, Ralfs.
ornatum, Ralfs.

Cosmarium Phaseolus, Bréb.
**præmorsum, Bréb.
*pseudo-connatum, Nordst.
**pseudo-nitidulum, Nordst.
*pseudo-pyramidatum, Lund.
pyramidatum, Bréb.
Ralfsii, Bréb.
tetraophthalmum, Kütz.
tinctum, Ralfs.
*truncatellum, Perty.
undulatum, Corda.
*variolatum, Lund.
Xanthidium armatum, Bréb.
Brébissonii, Ralfs.
cristatum, Bréb.
fasciculatum, Ehr.
Arthrodesmus Incus, Hass.
octocornis, Ehr.
Staurastrum aculeatum, Menegh.
alternans, Bréb.
Arachne, Ralfs.
*Arctiscon, Lund.
aristiferum, Ralfs.
*aversum, Lund.
Avicula, Bréb.
brachiatum, Ralfs.
**Brasiliense, Lund.
*Cerastes, Lund.
controversum, Bréb.
*cristatum, Näg. var.
cuspidatum, Bréb.
cyrtocerum, Bréb.
dejectum, Bréb.
furcigerum, Bréb.
gracile, Ralfs.
**grande, Lund.
hirsutum, Bréb.
**inflexum, Bréb.
læve, Ralfs.
*longispinum, Bailey.
margaritaceum, Menegh.
**megacanthum, Lund.
muticum, Bréb.
*Ophiura, Lund.
orbiculare, Ralfs.
paradoxum, Meyen.
* ,, var. longipes, Nordst.
polymorphum, Bréb.
*Pringsheimii, Reinsch.
Staurastrum **pseudofurcigerum, Reinsch.
punctulatum, Bréb.
**Sebaldi, Reinsch.
spinosum, Ralfs.
spongiosum, Bréb.
teliferum, Ralfs.
tetracerum, Ralfs.
tricorne, Bréb.
tumidum, Bréb.
vestitum, Ralfs.
Docidium Baculum, Bréb.
clavatum, Kütz.
Ehrenbergii, Ralfs.
minutum, Ralfs.
nodosum, Bailey.
nodulosum, Bréb.
truncatum, Bréb.
Tetmemorus Brébissonii, Ralfs.
granulatus, Ralfs.
lævis, Ralfs.
Closterium acutum, Bréb.
angustatum, Kütz.
attenuatum, Ehr.
Cornu, Ehr.
costatum, Corda.
*Cynthia, de Notaris.
Dianæ, Ehr.
didymotocum, Corda.
,, var. Baileyanum.
*gracile, Bréb.
intermedium, Ralfs.
Jenneri, Ralfs.
juncidum, Ralfs.
Leibleinii, Kütz.
lineatum, Ehr.
Lunula, Ehr.
moniliferum, Ehr.
Ralfsii, Bréb.
rostratum, Ehr.
setaceum, Ehr.
striolatum, Ehr.
turgidum, Ehr.
Penium Brébissonii, Menegh.
closterioides, Ralfs.
Cylindrus, Bréb.
Digitus, Bréb.
interruptum, Bréb.
margaritaceum, Bréb.
*Nägelii, Bréb.
truncatum, Bréb.
Spirotænia condensata, Bréb.
obscura, Ralfs.

A. W. WILLS.

January 20, 1881.

Plate V



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To this list of Desmidieæ found in North Wales must now be added the two rare species, *Cosmarium globosum*, Buln.; and *Staurastrum Saxonicum*, Reinsch.

At the time when that list was prepared, there was some doubt as to the identity of my specimens with the former plant, inasmuch as they do not correspond in certain particulars to the description published in "Rab. Fl. Eur. Alg.," nor yet to the figure given by Nordstedt in his "Desmidieæ Arctoeæ, 1875."

The kindness of Dr. M. C. Cooke has now enabled me to compare them with the original specimens of Bulnheim, published in "Rabenhorst's Alg. Exsic.," and I conclude that the species is subject to considerable variation, and that there is nothing in the form taken by myself in Wales to entitle it to rank as a distinct species.

Staurastrum Saxonicum has been twice figured by Reinsch, and between his two drawings there are material differences. My plant combines the characters of the two, and as I cannot identify it with any other known species, I conclude that it must really be referred to this rare form.

As neither of these plants has been hitherto detected in the British Isles, they must be added to our list as—

***Cosmarium globosum*, Buln.
***Staurastrum Saxonicum*, Reinsch.

There remain to be noticed three entirely new species, and as Dr. Cooke has already dealt with these in the last number of "Grevillea," I borrow, with his permission, the descriptions which he has given, adding figures drawn from my own specimens.

Cosmarium Cambricum, nov. sp., (Plate V., Fig. 1.)

Frond longer than broad; constriction, linear; segments, quadrilateral, narrowed from the base upward; sides, with two sinuations, and one in the centre of the end, the latter rather the broadest; side view, segments oval, narrow, rounded at the ends, with a shallow constriction; end view, elliptical.

Length, ·046—·048 mm.; breadth at the base, ·036—·038 mm.; at the end, ·02—·022 mm.

Allied to *C. tetragonum* and *C. Nymannianum*, from both of which it differs in the character of the sides and ends and the number of sinuations.

References to Plate V.

Fig. 1.—*Cosmarium Cambricum*.—Nov. sp.
,, 2.— ,, *coronatum*.—Ditto.
,, 3.—*Staurastrum anatinum*.—Ditto.
,, 4.—*Micrasterias Americana*, forma major.—Reinsch.
,, 5.—*Cosmarium cyclicum*.—Lund.
,, 6.— ,, *pseudonitidulum*.—Nordst.
,, 7.—*Staurastrum megacanthum*.—Lund.
,, 8.— ,, *Cerastes*.—Lund.
,, 9.— ,, *Arctiscon*.—Ehr.
,, 10.— ,, *pseudofurcigerum*.—Reinsch

It has been found in two or three stations in North Wales, but not elsewhere. The empty frond seems to be minutely punctate.

Cosmarium coronatum, nov. sp., (Plate V., Fig. 2.)

Frond about as long as broad, or rather shorter: constriction, deep, linear; segments, quadrilateral, narrowest at the base, and dilated upwards, very slightly convex at ends, rough all over, with elongated conical granules, arranged in lines, (about eight at the end and four on each side;) side view, truncate at the ends; end view, elliptical.

Length, ·065—·07 mm.; breadth, ·075—·08 mm.; isthmus, ·02 mm.; side view, ·045 mm. broad.

This resembles *Cos. biretum* in form, but the granules are conical and prominent, as in *Cos. Brébissonii*. The almost truncate ends, in front view, have eight of these conical projections, which impart a coronetted appearance.

In side view the ends are also truncate, which would be sufficient to distinguish it from closely allied species, and the regular elliptic ends separate it distinctly from *Cos. biretum*. By many features this seems entitled to rank as a distinct species.

Staurastrum anatinum, nov. sp., (Plate V., Fig 3.)

Segments in front view, broadly fusiform; rough with prominent granules, which are truncate on the outer margin; processes elongate, rough, terminated with minute spines. End view tri-radiate, processes elongate, rough, slightly and gradually concave, nodules at the centre truncate.

Length, ·05 mm.; breadth, including the processes, ·1 mm.; breadth at the sinus, ·02 mm.; length of the processes, ·025 mm.

Allied to *S. Sebaldi*, but differs in the front view in the broadly fusiform segments, and the upward rather than downward direction of the processes; hence the third process is usually visible on one or both segments in the front view.

Hence, if we denote new species by three asterisks, we may further add to our list—

****Cosmarium Cambricum.*
****Cosmarium coronatum.*
****Staurastrum anatinum.*

Dr. Cooke has figured the following new or rare forms found by myself at Capel Curig, in 1880, in recent numbers of "Grevillea," viz., *Staurastrum anatinum*, *S. aversum*, *S. Brasiliense*, *S. grande*, *S. longispinum*, *S. ophiura*, *Cosmarium pseudoconnatum*, *Docidium nodosum*, and the forms of *Tetrachastrum* representing *T. oscitans*, *T. mucronatum*, and intermediate ones.

I now add figures of seven rare species not hitherto figured in English works, all drawn from my own specimens, and to a uniform amplification of 400 diameters, in addition to the three new species described above.

March 15th, 1881. A. W. WILLS.

FRESH-WATER AQUARIA.

BY R. M. LLOYD.

Read before the Society, May 17th, 1881.

As much pleasure and endless subjects for profitable study are derivable from a well-managed fresh water aquarium, I offer a few hints on the subject, based on a somewhat successful experience of several years, and trust they may be of assistance to some of my fellow-naturalists.

The main point to be kept in mind, and on attention to which success chiefly depends, is the imitation of nature—that is, the subjects placed in an aquarium must, as far as possible, be surrounded by conditions which form a near approach to those in which they naturally grow and thrive.

Excluding the inhabitants of the sea, all the many and varied kinds of aquatic life may be roughly divided into those which live in ponds, or comparatively slow running streams, and those which live in rapid ones. This division will serve to indicate the reason why some animals cannot be kept in an aquarium, for, generally speaking, it is only those included in the latter group which do not thrive in an ordinary well-managed tank.

I have been many times asked the question: How often do you change the water?—and usually meet with expressions of astonishment when I answer that it is unnecessary to do so at all. Yet, if the inhabitants of the tank are in health this is quite correct, though it is well, as we shall presently see, to have an occasional "clean out."

There should be a proper proportion of animal and vegetable life in an aquarium, or rather a preponderance of vegetable life; for, although such animals as are carnivorous, and at the same time air-breathing, do not directly require it, yet, as they feed on those who are or have been either vegetarians or water-breathers, or both, indirectly they do; as besides forming food-stuff, plants are necessary to render the water capable of oxidising the blood of such of its inhabitants as do not derive their supply of oxygen directly from the air.

Water absorbs oxygen from the atmosphere by the simple contact of their surfaces, and if the superficial extent brought into contact is very greatly increased, as by the formation of waves, the flowing of a stream, and more especially by violent agitation, such as is caused by the beating of waves on the shore, enough oxygen will be absorbed to supply the animal inhabitants with all they require. As this cannot take place in pools or other small pieces of water, the supply must, consequently, be obtained in some other way. The action of the chlorophyll or the green colouring matter of plants on the carbonic acid gas contained in the water is the most constant method. It decomposes it into its two elements, carbon and oxygen; appropriates the former to its own use, and liberates the latter for that of animals.

Hence it will be seen that, although some amimals may be kept in an aquarium without plants living with them, it can only be by the aid of extraneous assistance; food must be placed within their reach; and the water must be aerated by agitation or some other mechanical means.

The first requirement is a vessel to contain the water. This may be made of almost any material, but the sides should either be vertical or inclined from the bottom outwards. "Fish globes," with the water-line above the greatest horizontal diameter, are to be shunned as the very worst form. A slate tank with plate glass front is by some considered the best vessel for an aquarium. I am, however, inclined to think that the use of rough plate glass for the sides and back would be an advantage, but an ordinary glass pan of about sixteen inches diameter and six inches deep will do exceedingly well; such vessels are sold under the name of "pastry pans," I believe, and cost about half-a-crown each. Ordinary propagating glasses inverted and held in position by a base turned out of a block of wood make very good tanks; small hand glasses, of about four inches diameter, placed on the top of hyacinth vases are also very useful, and are not unornamental. Pickle bottles, earthenware pans, and other such like ordinary vessels may frequently be used as auxiliaries with advantage.

The best water to use is generally that in which the animals have been found thriving, but such as is ordinarily supplied by water-works is admirable for aquarium purposes, being in many cases filtered stream water. Rain water will do for many things, but pump water is to be altogether avoided.

The bottom of the tank should be covered with about an inch of grit and fine gravel, on which it is well to place some pieces of rock or rough stone. It is better to avoid limestone in any form, and use slaty or siliceous stones only. Resting and hiding places are thus formed for the animals, and plants are better preserved from being uprooted.

I consider the American weed (*Anacharis Alsinastrum*) the best for aquaria, as none thrives so well or affords better food. It, moreover, furnishes a good example under the microscope of the circulation of cell contents, and the quantity of oxygen given off by it when freely exposed to the sun's rays is very great, the bubbles of gas ascending from it in continuous streams. The Anacharis also requires no care in removing and planting; any scraps thrown into the tank will soon send down rootlets from the joints and anchor themselves among the gravel; and even if any of the larger burrowing molluscs are kept in the tank, the plants, though being constantly uprooted, will still continue to grow. Microscopic treasures are frequently to be met with on it in abundance, but perhaps not so many in number as on the Water Milfoil, (*Myriophyllum*,) which is another very good plant for an aquarium. Chara and Nitella are also good. *Vallisneria spiralis* is very pretty and interesting, but it requires a rather deep tank, and its roots must be kept properly embedded among the stones at the bottom. I have kept Nitella for two years without it having at any time had its roots embedded.

I have always found my aquaria do best when placed before a window where they may have the direct rays of the sun for a good part of the day; the plants are thereby induced to grow vigorously, and these and the pieces of rock afford ample shade for those animals that require it. However, if it is not convenient to have it in such a position, any other will do, provided a fair amount of light can get to it. There may be, nevertheless, a disadvantage in an excess of direct sunlight. It causes the glass sides of the vessel to become covered with confervoid growth, which, although useful both as food stuff and for the evolution of oxygen, considerably obstructs the view through the glass, a desideratum, especially if a tank microscope is one of the possessions of the proprietor of the aquarium.

Water should be added from time to time to replace what has been lost by evaporation and other causes, so as to keep the level about constant. Dead animals should be removed, but decaying water plants, though somewhat unsightly, are such excellent harbour and food for microscopic creatures that they should rather be introduced than removed.

Occasionally, say once a year, in the late autumn or early spring, it is well to have a thorough clean out. At these times all the live stock which it is wished to preserve must be taken out, as also the pieces of rock and plants, and so much of the water as can be taken out in a clear state, drawn off with a syphon or otherwise carefully removed into another vessel, so that it may be returned to the tank together with the animals, plants, and stones after the cleaning process has been gone through. The reason for this is that there will probably be many germs in it, besides entomostraca, rotifers, and other small organisms which it is desirable to retain. The whole of the gravel and grit must be taken out and thoroughly washed. An enormous quantity of dirt will be found mixed up with the stones. This is chiefly the effete matter which, falling to the bottom, is hidden among them—indeed, this is one of the uses they subserve. If there are any snail eggs, vorticella, or other treasures attached to the glass, they should be carefully stripped off, and although they cannot be replaced in their original positions, they will, if returned to their renovated home, continue to develop or form new colonies, as the case may be. The glass, if there is any confervæ on it, should be well scrubbed with soap and warm water, taking care that all the sand and grit is removed, otherwise there will be most likely a number of undesirable scratches to be seen upon it.

In such an aquarium as has been described, almost any creature that inhabits fresh-water can be kept in health with little trouble, provided over-crowding does not take place; but due care must be exercised in the selection of its inhabitants. For instance, it will not be wise to place fish in it, if it is wished to preserve minute forms of life, these being their natural food. There should generally be a fair number of snails present, as they greatly assist in keeping the vegetation within reasonable bounds, and being particularly fond of confervæ, and very ravenous, the glass is usually kept fairly free from it, which, as we have seen, is desirable. The best species are *Lymnæa stagnalis*, *Paludina vivipara*, *P. contecta*, and any of the larger species of Planorbis ; *Planorbis corneus* being the largest, is to be preferred, but *P. carinatus*, *P. spirorbis*, as also *Lymnæa peregra* and *Bythinia tentaculata* are by no means unsightly, and are only inferior in point of size to the others above mentioned. Snails are exceedingly interesting objects in the very young state under the microscope, and the process of development in the egg can be better studied in those of the fresh-water mollusca than perhaps in any other. *Bythinia tentaculata* is the one of all others with which I am acquainted that arranges its eggs in the most convenient form for observation. They are placed in rows of two or three abreast and never on the top of one another. They are, moreover, of a comparatively large size, and their envelopes are very pellucid. The young of the Lymnæa, as also the full-grown Physæ, are very interesting to watch as they ascend and descend through the water by means of a mucus thread which they secrete, but which, ordinarily invisible, can be shown to be present by passing a solid body such as a glass rod between the animal and the point of attachment of the thread. The large bivalves, Unio and Anodonta, may be introduced into the aquarium, and they assist in keeping the water clear, but they draw into their systems through their fringed syphon tubes diatoms, desmids, rotifers, and other small swimming and floating organisms. If they are in a tank they should be watched and removed as soon as death occurs, which may be known by the gaping of the valves of the shell, since such a large mass of decomposing animal matter kills some of the other inhabitants very quickly, besides giving off a by no means agreeable smell. They will, however, under ordinary circumstances, live several years in confinement.

Polyzoa are generally not difficult to keep in an ordinary aquarium in moderate quantity. The statoblasts or "winter eggs" should be allowed to remain in the water, for though some of them float on the top of the water, or cling to the sides of the tank, giving it a somewhat untidy appearance if they are in considerable numbers, yet the beauty they display when they burst, and the young individuals come forth, amply atones for the former slight unsightliness. The statoblasts may, however, if desired, be removed, and placed in an auxiliary tank to be kept through the winter. Indeed, it is a verv good plan to keep specially interesting microscopic beings in separate small glass vessels, as they are the more conveniently got at when required for examination, and can also the better be preserved from their natural enemies.*

* Mr. Potts has introduced an admirable form for this and other purposes. It is in shape a large Zoophyte trough about 4in. in height and width. It has an extended base, so that it will stand in a window, and the depth from front to back being 1in., a pocket lens can conveniently be brought to bear upon anything in it. They are to be had at Miss Bailey's, in Bennett's Hill, Birmingham.

Fish, as has been mentioned, are usually not very desirable tenants, as they will not join the union and become members of a "happy family." The species best suited for confinement are the Roach and Prussian Carp. These may be transferred from their native waters direct, but the Perch, Pike, and Minnow, which also do well, should first be placed in a vessel where the water is changed, but at gradually increasing intervals, and in about a week or ten days they may be placed in their future permanent home. Gold and Silver Fish, as is well known, thrive well in a small tank, so does the common Stickle-back, or Jack Bannel. This latter is one of the most interesting fish we have, as it builds a nest for its young, and in the spring-time the male is very gorgeous in his rainbow hues. The spawn and fry of fish can be kept, and are well worthy of examination with the microscope, being especially instructive as examples of embryonic development of vertebrates. It must be borne in mind that many creatures feed on the fry, their own parents included. Beetles may be placed in an aquarium in almost any numbers, but they will soon be reduced to a very small one, as they are exceedingly voracious, pugnacious, and regular cannibals.

Many other animals besides the few indicated may be kept in an aquarium, but overcrowding will cause great mortality. If convenient, it is well to have several large tanks, so that those animals which will not keep the peace with their fellow-lodgers may be separated. It is also a good plan where objects for the microscope are specially wished to be always at hand to have one tank very stagnant, *i.e.*, where the conferva is encouraged to grow vigorously and never cleaned out; but if the hints given above are followed, a great number of species may be kept and will flourish in a single tank.

NOTES ON BOPYRUS SQUILLARUM.
A PARASITIC CRUSTACEAN.

BY W. R. HUGHES, F.L.S.

Read before the Society, May 31st, 1881.

In looking over a collection of miscellaneous marine specimens, the proceeds of many a pleasant dredging excursion, which had accumulated during several years, with the view to find some worthy of the museum of this noble college, I found one—the subject of these notes—which I took at Torquay in 1867, and which, as I do not remember to have seen it exhibited here previously, I think may occupy our attention for a few minutes before it follows the example of its fellows. *Bopyrus squillarum* is a small parasitic crustacean, of pear-like shape, which selects for its habitat a position beneath the front shield or carapace of the common edible prawn, *Palæmon serratus*, and some other allied forms, the presence of the female causing a large tumour of nearly half-an-inch in diameter on the side where the parasite affixes itself (Fig. 1), the tumour being largest when the parasite is distended with ova. *Bopyrus* belongs to the second of the two great divisions into which the Crustacea have usually been separated—the sessile-eyed, that is to say, those whose eyes are not placed upon footstalks, the other division being termed the stalk-eyed. It is of the order Isopoda (equal feet), in which the legs are adapted for walking only, first named by Latreille, and so founded in contradistinction to the order Amphipoda (both feet), the members of which have both swimming and walking feet.

The family of the Bopyridæ, which includes *Bopyrus squillarum*, is small, numbering only four genera, but according to Messrs. Spence Bate and Westwood, the able historians of "The British Sessile-Eyed Crustacea," "it exhibits some of the most remarkable modifications of structure amongst its different members, whilst the characters of the group render it a very distinct one amongst the families of which the order is composed." Limiting for the present a comparison of this singular organism with a high type of the crustacea—say its host *Palæmon serratus*, the common prawn—we shall be able to gain a conception of the remarkable modifications which *Bopyrus* has undergone, if we assume, according to the laws of evolution, that they have both originated from a common progenitor.

Description of Plate X.

Fig. 1 gives the Prawn and its parasites *in situ*; Fig. 2 gives a dorsal view of the female parasite; Fig. 3 gives a dorsal view of the male parasite; Fig. 4 gives the male parasite in the folds of the pleon of the female; and Fig. 5 gives the nauplius stage of the parasite. Figs. 1, 2, and 4 are sketched from preserved specimens. Figs. 3 and 5 are copied from "The British Sessile-Eyed Crustacea," by Messrs. Spence Bate and Westwood.—I am greatly indebted to Miss Hadley for making the illustrations.—W. R. H.

PLATE X.

Bopyrus Squillarum.

The appearance of the ordinary edible prawn is familiar to all, and its elegant and vivacious movements in the aquarium have delighted and amused thousands of observers, to say nothing of its gastronomic qualifications, which appear to have been appreciated, if not entirely understood, in Shakespeare's time, for Hostess Quickly says to Falstaff in the Second part of King Henry IV., "Did not goodwife Keetch, the butcher's wife, come in then and call me Gossip Quickly? coming in to borrow a mess of vinegar; telling me she had a good dish of prawns; whereby thou didst desire to eat some; whereby I told thee they were ill for a green wound?"

Without going too much into technical details it is sufficient to say that the prawn consists anteriorly of a chitinous shield or carapace, from which extends a rostrum armed with seven or eight teeth. The animal has three pairs of antennæ—the external ones being very long—half as long again as the animal itself from the tail to the extremity of the rostrum. The eyes are large, round, and projecting. It has five pairs of thoracic feet, two of which are furnished with chelæ or nippers for prehension, the second pair being much the larger and stronger. Beneath these are the jaws (maxillipedes) and a wonderful alimentary apparatus for food crushing and filtering, which has been minutely described by Professor Huxley in an allied form in his magnificent monograph "The Crayfish." The remaining three pairs of feet are devoted to purposes of walking. These limbs carry eight respiratory gills (podobranchiæ) attached to the basal joint, and placed under cover of the carapace. Posteriorly the prawn has six movable abdominal segments (or somites), the last one (or telson) terminating in a triangular joint, to which are attached on either side two laminæ furnished with hairs, forming the tail. These segments carry anteriorly five pairs of swimmerets, "which are used like paddles when the animal swims quickly." The ova find lodgment on these limbs. As is very well known, the prawn and its congeners are subject to periodic moults. Notwithstanding its comparatively small size and slender figure it would, I think, be difficult to conceive an animal better adapted by the shapes and positions of its organs to fulfil its functions—the delicate, long, and sensitive antennæ used as organs of touch, and perhaps of smell, the prominent compound eyes with a wide range of vision, the strong-toothed rostrum projecting from the stout carapace for poking about for food in the crevices and crannies of rocks, the nimble hands for seizing it, the graceful and active walking and swimming feet, the muscular segmented body and tail adapted for darting through the water and enabling the prawn when in full health to evade, perhaps, most of its enemies, except man with his prowling "shrimp net." The organism is greatly but not completely in harmony with the environment. And from the fact that it delights in a habitat between tide marks, it has acquired, as any observer may have noticed in watching the movements of prawns frequenting rock pools, an intelligence and boldness that must aid it in "the struggle for existence." Many littoral marine animals of high type, as crustaceans and fishes, frequenting a varying environment, appear to have acquired a superiority of intelligence over those confined to deep water where the conditions of life remain unchanged.

In the "Principles of Biology," and in that division of it which treats of the morphological development and of the general shapes of animals, Mr. Herbert Spencer has pointed out, *inter alia*, that the structure of decapodous crustaceans, as represented by the prawn, exhibits an advance in structure over the isopodous crustaceans, and a marked advance over such creatures as the centipede and *julus* types, any one of which latter animals (all the segments being nearly uniform) may be bisected transversely into parts differing very slightly from each other: but if cut in two horizontally the under and upper halves are decidedly unlike, whereas the head and tail of the prawn show a very marked contrast and an advance in structure over the other segments. Of bilateral symmetry, and in comparative harmony with the environment, the incidence of forces being equal, the common prawn exhibits a striking contrast to *Bopyrus*, as will hereafter appear. Doubtless "the sum of the vital activities" of the prawn, as Mr. Herbert Spencer would express it, is much greater in any given interval than that of many members of its own class, and greater even than animals of higher type, such as the oyster and others, which lead sedentary lives.

In *Bopyrus*, what first strikes one as being noticeable is an absence of the symmetrical arrangement of *Palæmon*, which characterises the female *Bopyrus*, giving a strange lop-sided appearance to it (Fig. 2), although the male (Fig. 3), being free, is symmetrical. From the peculiar position of the female in the carapace of the prawn the incidence of forces is unequal. Next is the disparity of size between the sexes, the female being about five times longer than the male, which is only one line in length. This rule obtains sometimes in the *Insecta*, but not markedly so in the higher *Crustacea*. The female of *Bopyrus* is broad and ovate, while the male is elongated. Further, the segments of the body of the female appear but faintly, those of the male on the contrary being well marked and distinct. The head (cephalon) is almost immersed in the body of the female, but is better developed in the male, the eyes appearing distinct. The antennæ in both sexes are very short and rudimentary, and so is the mouth, which, according to Spence Bate and Westwood appears to lose much of its normal character, and as one would expect from the parasitic nature of *Bopyrus*, fulfils the office of a sucking apparatus. The seven pairs of legs are almost of equal size, strong and thick, and furnished with a well-developed broad hand, strongly hooked for prehension. The tail (pleon) is well marked in both sexes. The females are furnished with large incubatory plates. Not only in *Bopyrus*, but throughout the curiously degraded family of the Bopyridæ, the branchial organs "are depauperated to the lowest degree," being little more than excrescences on the under side margins of the tail. Beneath the plates covering these the male is usually found. Fig. 4 exhibits the male *in situ*. The colour of the female *Bopyrus* is pale green, and the body is not of strong consistence. The young *Bopyri* are of an oval form, somewhat like a wood louse, with the outer pair of antennæ greatly elongated, carrying slender setæ. The legs are sub-chelate, and the tail carries two pairs of joints, terminating in setæ. It appears that in the nauplius or larval condition (Fig. 5), the young exhibit the most advanced stage of development: according to Spence Bate and Westwood, "the organs of sense and motion being proportionately larger and better developed at that period of their existence than ever after." Messrs. Spence Bate and Westwood further say: "It would thus appear as if the nervous energy was then greater, and that the growth of males and females is but what Dr. James D. Dana calls a vegetative process, and one that is destructive of cephalisation, which decreases in proportion to the growth of the animal. They therefore argue that of the adult *Bopyri* the smaller male ought to be taken as typical of the species rather than the more abnormal female." I particularly direct your attention to the fact of high development in the nauplius stage as a most remarkable illustration of that special branch of modern biological speculation termed phylogeny, which professes "that the development of any organism should furnish the key to its ancestral history."* It would appear from this that *Bopyrus* is derived from some more perfect form of crustacean, and that its degraded organs in the female in maturity are due to its peculiar environment within the carapace of the prawn. The *Bopyri* seem to gain access to the body first by sheltering in the early stage among the freely hanging ova of the prawn. They work in pairs, as appears from a communication to the Proc. Zool. Soc., November 24, 1863, afterwards finding their way into the carapace, and so, as the authors I have quoted say, "having quitted the care of their own parent they are fostered by another on whom probably at a later period they prey parasitically." As with most parasites the fecundity of these creatures is considerable, no fewer than 800 young being nourished in the incubatory pouch of the female. Most of these perish, for only one mature parasite and its mate infest their host at one time.

The question has been asked as to what becomes of the parasite during the periodic moults of its host. I have not been so fortunate as to take a prawn in this condition infested with *Bopyrus*, but I apprehend that the number and strength of the well-hooked hands are quite sufficient to retain the female parasite in position during the moulting process of its host. Another interesting question suggests itself. What becomes of the exuvium of *Bopyrus* during its period of moulting, and in what way is this removed? Does it disappear only during the moulting process of the prawn?

* *Vide* "A Manual of the Anatomy of Invertebrated Animals." By T. H. Huxley, LL.D., F.R.S., 1877. Introduction, page 41.

The existence of *Bopyrus* has been known for some time, but not properly understood; for in the year 1772 Mons. de Bondaroy, a French naturalist, published a memoir on *Bopyrus squillarum* disproving the old fallacy entertained by fishermen on the coasts of France that *Bopyri* were the young of soles or other flat fish, which took shelter under the shell of the prawn to protect them in their early stages of growth—an idea held even by some scientific men at that period. In the year 1837 Rathke made some interesting observations upon *Bopyrus*, showing from an examination of a number of specimens that they usually infested the *female* prawn only, for out of several hundreds infested the male prawn was free. It appears to me that we have not to go far to seek an explanation of this. The ova of the prawn afford a "fitting environment" for the young *Bopyri*, which need to be sheltered in their early stages preparatory to their entrance under the carapace of their host. It is, therefore, not too much to say that in this instance their very existence is dependent on the fertility of the prawn.

Dr. Fritz Müller made, in the year 1864, a very remarkable observation on a member of the *Bopyridæ*, which he communicated to the authors of the "British Sessile-Eyed Crustacea." He says: "One of the most interesting animals of this family is a *Bopyrus* living on *Pagurus* (a genus of the hermit crab), in which the dorsal surface of the parasite is directed towards the *Pagurus*. (He therefore named it *Bopyrus resupinatus*.)" The origin of this curious mode of attachment is the following:—The larva of *Bopyrus* affixes itself to *Sacculina purpurea* (another parasite of the non-segmented suctorial order of crustaceans (*Rhizocephala*) living on the same *Pagurus*), and takes its nourishment from the roots of the parasite. After the death of the *Sacculina*, to whose central surface the *Bopyrus* was fixed, the latter probably cannot change its position, and remains with its dorsal surface facing the *Pagurus*.

Finally, in briefly contrasting together the two adult animals, the host *Palæmon* and its parasite *Bopyrus*, we have the symmetrical, compact, segmented body of the one, and the unsymmetrical body of loose consistence of the other—the cephalothorax with its stout rostrum and compound eyes gives place to a mere extension of the body of the other—the complicated mouth of the one is represented by a mere sucking apparatus in the other—the long and sensitive antennæ of the one are represented by mere aborted extensions in the other; the ramifying branchiæ of the one give place to rudimentary organs in the other; the long, slender, and graceful walking and swimming feet of the one are represented by dwarfed limbs in the other; but, as a compensation, and the only one of the greatest importance to the parasite, the hands are both strong and numerous to aid it in grasping and holding on. *Bopyrus* exemplifies in an eminent degree a retrogressive phase of the theory of evolution. *Palæmon*, on the contrary, illustrates a progressive phase of that great theory.

If I have at all succeeded in enabling the members to gain a conception of the relative differences, not only between the typical crustacean as host and its particular parasite under consideration, but also between the different stages of growth of that parasite, I think they will agree with me that no better illustration could be adduced of "the effects of use and disuse of parts," and of the "adaptation of the organism to its environment." As Mr. Herbert Spencer has pointed out in the "Principles of Biology" before referred to, animals of the Annulose type become unsymmetrical when their parts are unsymmetrically related to the environment. The common hermit crab (*Pagurus*) furnishes an illustration like *Bopyrus*. The embryos of each of these creatures are symmetrical, but the curvature of the body of the hermit crab is due to the position it acquires to adapt itself to the shell which it inhabits, and the unsymmetrical condition of the adult *Bopyrus* is similarly due to the position it occupies within the carapace of its host the prawn. Except for the writings of Dr. Darwin and Mr. Herbert Spencer * such biological problems as that presented in the morphology and degraded structure of *Bopyrus* would be totally inexplicable. Thanks, however, to the light thrown on these questions, especially by the illustrious author of "The Origin of Species," a new significance is apparent, and as he has shown in that wonderful work, "any change in function which can be effected by insensibly small steps is within the power of natural selection; so that an organ rendered, during changed habits of life, useless or injurious for one purpose, might be modified and used for another purpose." And again: "Rudimentary organs may be compared with the letters of a word, still retained in the spelling, but become useless in the pronunciation, but which serve as a clue in seeking for its derivation."†

Bopyrus, so far as the female is concerned, is apparently getting worsted in the struggle for existence. One cannot help thinking that in the distant future its lease of life will not be remarkably long. So much the better for the prawn!

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* *Vide* "The Principles of Biology." By Herbert Spencer, 1867. Vol. II, page 183, *passim*.

† "Origin of Species," pp. 52, 40. *Fourth Edition*, 1866.

HOW TO WORK IN THE ARCHÆAN ROCKS.*

BY C. CALLAWAY, M.A., D.SC. (LOND.) F.G.S.

The Archæan (Pre-Cambrian) rocks have recently excited considerable interest, owing partly to the more or less complete working out of the younger groups, and partly to the fascination which attends a study of peculiar complexity.

In America, six Archæan systems have been described, which, taken in descending order, are the following :—

I.—*Keweenian*, or copper-bearing series of Lake Superior.
II.—*Taconian.*
III.—*Montalban*, or mica-schist series.
IV.—*Huronian.*
V.—*Norian.*
VI.—*Laurentian.*

In Britain, Murchison recognised the Laurentian in the great gneiss series of the Hebrides, and Dr. Holl claims the same antiquity for the Malvern ridge. Salter and Hicks discovered two Archæan groups, Dimetian and Pebidian, at St. Davids. Two Archæan formations have also been recognised in Carnarvonshire, and the writer has worked out two groups in Anglesey. He has also discovered two series, a volcanic and a metamorphic, in Shropshire, and has detected the former on the flanks of the Malverns. The slaty and brecciated rocks of Charnwood Forest have also been referred to the Archæan by Dr. Hicks, subsequent to their description by Messrs. Hill and Bonney.

Notwithstanding the peculiar difficulties attending the study of these rocks, there is no reason to despair of success, and, in this paper, the methods of work are indicated.

The evidence of *organic remains* is rarely applicable. The organic nature of *Eozoon* is strenuously disputed, and, in the present state of the controversy, the (so-called) fossil is of little value as a test of age. Besides this, a similar structure has been discovered in the Taconian, and Murchison even claimed it as a Silurian fossil. The traces of annelides, which are found in some very ancient rocks, are hardly distinguishable from recent tracks and burrows, and are of little classificatory use.

The test of *order of superposition* is frequently complicated by *inversions*. In North America the Archæan rocks have a general south-east dip, but really they are made up of numerous parallel folds, with their summits thrown over to the north-west. The contorted schists of Anglesey display the same phenomena. The contortions have been disentangled by the discovery by the writer of a grey gneiss underlying the prevailing green schist, and the latter is seen to lie in sharp synclinal folds between anticlines of the gneiss.

The superposition test is also complicated by *faulting*. The

* Summary of a paper read before the Society, on June 28th, 1881. Published in full in the "Geological Magazine."

Archæan groups in Britain are generally brought against the Lower Palæozoic Rocks, and against each other by faults. In Anglesey and in Ireland, the ground occupied by the Archæans is almost literally a pavement of fragments. The difficulty thus arising may sometimes be surmounted by the following method. An actual example will make the matter clearer. In central Anglesey, there is a broad band of granitoid rock passing down into green schist, but as the area is margined by faults, the succession cannot be traced down lower: but two miles to the east, we again come upon the green schist, and by following the section to the west, we find the schist is underlaid by a succession of gneissic rocks. The green schist thus connects the two areas, and enables us to construct a complete succession.

The test by *included fragments* is often of great service in these old rocks. Three examples of its value are here given. The plum-coloured conglomerates of the Longmynd (Lower Cambrian), in Shropshire, are largely made up of a purple felstone, which is common in the Wrekin volcanic series, which is thus proved to be Pre-Cambrian. The Wrekin group itself contains conglomerates whose pebbles are varieties of metamorphic rock which have been derived from a series of which Primrose Hill, near the Wrekin, is a denuded fragment. The existence of two Archæan groups in Shropshire, a volcanic and a metamorphic, is thus proved. The third example is in Anglesey. Conglomerates, proved by their fossils to be Cambrian (Tremadoc), contain pebbles of granitoid rock and schist, together with rounded fragments of green and purple slate. It is clear that these conglomerates have been formed from the denudation of the two other formations which occur in the vicinity, a Gneissic and a Slaty group, both of which are thus proved to be Pre-Cambrian or Archæan.

But the test by included fragments must be used with caution. In volcanic formations there may be contemporaneous denudation, and a conglomerate may be derived from a lower part of the same series. Such conglomerates, with pebbles of purple felstone, occur in the Wrekin series, and their included fragments are of no classificatory value.

The *mineral composition* of rocks, often an important test even in fossiliferous deposits, as the chalk or the Zechstein, becomes of supreme value amongst the Archæan groups. Thus the green schist of Anglesey, as previously shown, becomes a connecting link between areas separated by faults, and is as readily recognised in any part of the island as if it contained fossils. Thus also the slaty series of Anglesey is inferred to be Pebidian, by its close mineral resemblance to the typical Pebidian of St. David's. Indeed, this test is our chief guide amidst the complexities of these old rocks, and its use has led to some of our most interesting discoveries. Due caution must, however, be exercised in its application.

This kind of evidenoe decreases in value as the formations compared increase in distance. There are, for example, volcanic rocks similar to the Wrekin series, both at Pontesbury, near Shrewsbury, and near Bangor. But it is obvious that the evidence for the correlation of the Pontesbury rocks with the Wrekin group, from which they are but a dozen miles distant, is incomparably stronger than the proof of the contemporaneity of the Bangor series, which is separated from the Wrekin by the breadth of North Wales.

In estimating the value of this test, it is first of all necessary to ascertain if the rocks under investigation are *older than the Cambrian.* The Charnwood slaty series, for example, can only by superposition be proved to be pre-carboniferous; and the evidence for its Pebidian age is, therefore, much weaker than the proof adduced for the Anglesey slaty series, which is proved by included fragments to be Pre-Cambrian.

An important accessary test is *similarity of succession.* Thus the green schist on the Menai Straits closely resembles the rock underlying the granitoidite in the centre of Anglesey. But it would be just *possible*, were there no other evidence, that the resemblance was a mere coincidence. The discovery, however, of a grey gneiss under the green schist in both areas removes the doubt; for that the similar succession should be due to coincidence is simply incredible.

In comparing formations by their mineral characters, it is requisite to take them *as a whole.* Rock specimens selected with a view to favour a preconceived theory will lead to the most bewildering results.

The *degree of metamorphism* of a rock-group is an important factor in the evidence. Recent investigations favour the conclusion that, at least in England and Wales, all metamorphosed or partly altered groups are Archæan, and that the intensity of the alteration is proportioned to the age of the series. All the cases of metamorphic Cambrian and Silurian, adduced by Murchison and others, have, on re-examination, broken down, and there would appear to be some grounds for constructing an empirical rule that, within the above limits, any new area of regional metamorphism which may be discovered would probably be Archæan. Numerous proofs of these points might be adduced, if space permitted. It is, of course, necessary in these studies to bear in mind the influence of *selective metamorphism.* A quartzose rock, for example, can undergo little change, whereas a felspathic rock, though of less antiquity, might be intensely metamorphosed. We must also carefully distinguish between *regional* and *contact* metamorphism. The presence of the latter would be of no assistance in our work.

In correlating Archæan groups, it is important to ascertain the *origin* of the deposits; whether, for example, the rocks were sedimentary or volcanic, or both. If successful in this point, we narrow the issue to be decided.

The *microscope* is of great value in these investigations. It gives precision to field work, and discovers facts which field tests are not competent to ascertain.

The *strike* of a series has often been used as an aid in correlation, and, within due limits, it decidedly adds to the weight of other evidence.

In conclusion, it is to be observed that in Archæan work the proof is generally *cumulative*. Results are often obtained by the accumulation of minute facts, most of which cannot be published, or even recorded without incalculable labour. Each tap of the hammer helps to build up the conclusion. Different lines of evidence, each of which taken alone would fail to convince, converge towards the final issue. *Thorough* and *detailed* labour is above all necessary. With patience and zeal there is no reason why the Archæan fields of work, barren as they appeared to our predecessors, should not yield most fruitful additions to our knowledge of the early history of the globe.

ON COMMENCING THE STUDY OF FUNGI.*

BY DR. M. C. COOKE, M.A.

It is contrary to my wishes that I should come here for the first time with an apology in my mouth; but so the fates have decreed. If you are disappointed, I shall be none the less so, that I am incompetent to the duty laid upon me. Congratulating you on having commenced this year a most interesting study, I must warn you that it is not an easy one. If any of you would go further than you have gone to day, it must be by dint of work. There is no royal road to a knowledge of fungi. After a quarter of a century of too close application, as the sequel has proved, I am still but a learner. I am still fain to confess how much there is I do not know.

Out of more than 3,000 British fungi, perhaps near 4,000, there are 1,000 or more which may be collected and studied without the microscope, by the aid only of a simple pocket lens. This group is perhaps the best known as Fungi. Some there are who know no other. They are the mushroom and toadstool kind, and those hard woody excrescences which are not uncommon on rotting trees. These are called by fungus hunters, *Hymenomycetes*, because the spore-bearing surface forms a distinct, exposed part of the fungus, as for instance the gills of a mushroom or the tubes of a polypore.

I need not enter upon either the minute anatomy or the classification of these higher fungi, but simply call to your mind that the spores, or analogues of seed, which they all produce are borne on the tips of clavate basidia, or fruit-stalks, which are surmounted by two or four little spicules, each of which carries a spore. If we take a mushroom, or a fungus of the same genus, in our hands, and examine it, we shall observe that the cap or pileus has on its under surface a number of radiating plates or gills, the whole surface of which is covered with the basidia I have just spoken of, closely packed together, and bearing on the spicules at the tips the spores of the fungus.

These spores differ in colour in different species, and the species are grouped together according to the colour of their spores. The Agarics with white spores equal in number all the rest with coloured spores. In some they are roseate, in others brown, in others purple, in others black. In determining a fungus, *the first thing to ascertain is the colour of the spores.* To facilitate this it is better to cut off the stalk and place the fungus, gills downwards, on dull black paper, and allow it to remain all night. During this time the spores will be thrown down upon the paper, and their colour can be determined. If the operator is also a microscopist, he may examine some of these spores in a drop of water, and discover their form and size, as well as their colour.

* Presented to the Society, at the Fungus Foray, October 8th.

Having experimented thus far, the novice will learn the meaning of the five groups into which the large genus *Agaricus* is divided in the handbooks. These divisions correspond with the colour of the spores.

Let us return again to our type mushroom or toadstool, and look once more at its composition. Some of them will have, as the mushroom has not, a sheathing cup or membrane at the base of the stem, and portions of the same membrane adhering like warts to the cap. This will indicate the essential features of a sub-genus with a comparatively limited number of species. Others, deficient of this volva, will have a ring round the stem, others again will have no ring. Then the gills must also be observed. In some the end next the stem does not touch the stem, in others it joins the stem, and in others it not only joins, but is decurrent, or runs some distance down it. By observing closely all these minute details, and many more, such as the smoothness or roughness, or silkiness of the cap, whether dry or viscid, elevated or depressed, you will at length be able, by dint of patience and perseverance, to determine for yourselves with tolerable accuracy the name of any Agaric which comes into your hands. Remember that all the most apparently trivial and minute differences must be sought out and made note of.

The faculty of close and accurate observation is the great desideratum of the fungus hunter, as of all students of natural history. Those who have learnt how to observe will make the most rapid strides in Mycology. The most important of all faculties is that of knowing how to see, and, to some extent also, how to taste and smell.

You will pardon me if I omit to dwell on the distinctions between the genus *Agaricus* and the other genera closely allied to it, which would occupy considerable time, and are best learnt in the field with the aid of a knowing friend and a little experience.

Other large fungi you may have seen which have no gills on the under surface of their caps, but in the place of them there are a number of pinholes, which are the openings of tubes, the sides of which are lined with the basidia. The fleshy sorts are called *Boletus*, the harder woody kinds are *Polyporus*. If you cut one of them longitudinally through the stem, if it has one, you will see and learn better than by verbal explanation the difference between them.

Take up yet another fungus, and in place of either gills or pores, you will find teeth or spines, with the spore-bearing surface investing them on the outside. Thus, through all the various orders and genera of the higher fungi, you will find special modifications of structure, which are set forth in the written characters of the orders and genera under which all the species you may meet with will find their allotted place, and your progress will be very much indicated by the facility with which you may place every new comer into its own especial pigeon-hole.

I may naturally expect you to ask me, having found, and, perhaps, named a number of Agarics, what you are to do with such putrescent plants, in order to have some record of your labour I *cannot* recommend you to waste your time in attempting to cut them in slices and dry them, since, when you have done so, they will give little or no idea of the living plant. There is only one alternative—*you must learn to draw and colour them to the life.*

This is not such a fearful task as it may seem, and, with a little experience, one who has had no practice in drawing will be able to do it very well. Permit me a hint or two to those who persist in affirming that they cannot draw. Take your Agaric, with a sharp knife cut it right through the cap and down the stem into two equal halves. Lay the cut surfaces a minute or two upon blotting paper to absorb moisture. Then take one-half and lay it, cut surface downwards, on paper for drawing. Hold it there, or pin it there, so that it shifts not. Then with a sharp pencil mark round the cap, gills, and stem, tracing the form accurately on the paper. Remove the half fungus, and complete the drawing by hand along the upper edge of the gills, so as to present a correct outline of the cut section. This done, see that you mark also the hollow of the stem if it is hollow, and then proceed to colour the gills of the natural colour, if they are not white, and then the inner surface of the stem, or wherever colour is requisite to a perfect section. Having a perfect and accurate section, you have obtained half of what is necessary. Lay the same, or the other half, on the paper, and trace again in the same way; but, instead of tracing the gills, leave off at the edge of the cap, remove your section, draw a connecting line across from one edge to the other of the cap, and you have an outline of the growing fungus, drawn mechanically. Colour this also as near as you can in imitation of the living specimen. By getting over the difficulty of drawing by this method, the minor difficulty of colouring will soon be overcome, and, after a time, the mere tracing will so accustom the hand that you will be able to accomplish artistic drawing.

On these rough drawings may be written all the details which could not be well represented. It may be necessary in your earliest attempts to write the name beneath; you should add where found, if on the ground or on wood, whether it was viscid or dry, dull or shining, fœtid or without odour, etc. These, roughest of all drawings, will serve to remind you of all the features of species you have seen. Take special care to omit nothing that you can see and recognise in the living plant. If you wish to preserve the spores you can obtain them in the method already described, and, folding the paper so as to prevent their rubbing off, attach them to your sketches.

For a few minutes permit me now to answer the question which some one might propound—"Cui bono?"

There is less asking of such a question now in respect of any natural history pursuit than there was forty years ago. You must apply for yourselves all such general answers as will apply to *all* the departments of biology.

I will attempt only two or three, which are special to the subject. First,—The field is so little trodden that you are sure to bring credit to yourself by your investigations; and you will probably soon receive encouragement by some discovery, either of new forms or new phases, such as the well-worked entomology could not so readily furnish. Secondly,—Your acquisition of practical knowledge may add very considerably to your creature comforts. Taking, as a low estimate, fifty species found in this country to be good eating—and some are delicious—you will be able to add a few choice dishes to your table, and to invite your friends to repasts of which they had not before tasted. I have never recommended anyone to experiment with fungi, but I *do* recommend those who are able with certainty to distinguish one fungus from another, as readily as they can distinguish a chaffinch from a crow, to eat such as are edible, because no two of them are exactly alike, and some of them will produce quite a new sensation, and will remain a standing dish at your table for ever after. Eight or nine gentlemen of my acquaintance once supped with me, now twenty years ago. They were beguiled to eat of a mysterious dish. It was fried puff-ball. Not one of them now living has forgotten that supper, and it is almost always mentioned when we meet, for meetings are rare with old friends, and the reminiscence always affords pleasure, as did the repast.

Prejudice is very strong against eating any fungus but that called the Mushroom, and yet I suppose that I have eaten forty others which are quite as harmless, some quite as good, other perhaps better, and all quite as easy of determination—some more easy, for they can scarcely be mistaken.

I think a successful appeal to an Englishman's stomach needs no further answer to "what good is it?" I must now crave permission to conclude with a word or two of counsel.

Do not imagine that there is any royal road to the knowledge of fungi. The only road is patience and perseverance.

Do not despair because you fail ten times in determining a fungus accurately, for many have failed before you.

Do not rest satisfied with having your specimens named for you. It is better to make out a few for yourself than only to learn them empirically by being told their names, and never learning the reason why. It is useful to have a few species pointed out, or a difficult problem solved; but this being done, the next step should be to compare the specimens carefully with the description in the book, and see how the two things agree. Never take upon trust what is told you, if you have the opportunity of verifying for yourself. The road to truth runs through the portals of doubt.

In my experience I have known many who call themselves naturalists, who collect a batch of specimens, trouble themselves not for an instant to determine what they are, but pack them off at once to some expert, with a polite note, "Please to inform me of the names of the enclosed." Such a proceeding is not only a disgrace to any intelligent man, but it is also a shameful tax on the energies of the too willing expert, who, like a true naturalist, is ever willing to extend a helping hand. I have known persons to follow this process year after year, sending the same common thing three or four times over, and even after ten years not a step beyond the point from which they started.

It is only we, who follow a specialty, who know the extent to which this brass is passed as gold. Depend upon it, we can form our estimate of men who make collections, and borrow reputations, at the cost of other men's brains.

Do not imagine that you are failing because you cannot appraise your own success. You may seem to stand still, and yet, if your work is earnest and genuine, you will be progressing. Acquisition of knowledge can never be set down as a failure; and one cannot cut up and examine plants, whether fungi or others, one after another, and not acquire knowledge. True knowledge is not showy and pedantic. A little popgun may make a great noise.

Do not attempt too much. Confine your operations to some definite limit. Let the Agarics, for instance, be the summit of your ambition, and do not attempt more till you comprehend the method of classification, and have laid a good foundation; then you may go on and add another story to your house. Attempting too much means failure in all. You know what we think of a man who knows a little of everything—the title of every book, the mysteries of every trade. We know also the success which men have achieved by confining themselves to a small group of insects, to a single order of plants, and how easy it is for them to add another, and another, when they have learnt one thing well.

BIRMINGHAM NATURAL HISTORY

AND

MICROSCOPICAL SOCIETY.

REPORT & TRANSACTIONS

FOR

THE YEAR 1882.

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CONTENTS.

TRANSACTIONS.

ADDRESS OF THE PRESIDENT,

MR. J. LEVICK,

DELIVERED AT THE

ADJOURNED ANNUAL MEETING,

APRIL 3rd, 1883.

MR. PRESIDENT, LADIES AND GENTLEMEN,—

When you did me the honour to elect me to fill the high office I have lately vacated, I felt, among many shortcomings, that the want of ability and leisure for any original work of value which I could submit to you in the shape of a retiring address, would be the last, but probably greatest, of my difficulties.

The very kind and cordial co-operation of the Officers and Committee has enabled me to get through the other duties with pleasure, and I take this opportunity of tendering my sincere thanks to those gentlemen in particular, and the members generally, for the kindly way in which they have received the imperfect services I have been able to render. I have always had the interests of the Society very much at heart, and can never think of our library, instruments, and general standing without feeling deeply indebted to those members who acted as pioneers in former times, and have safely established us in our present position.

Now I have given much anxious thought in considering what I could do that might be of some little interest to you, and in asking your indulgence while I submit the following notes, I am encouraged by the fact that while our Society has many members who hold exceptionally high positions in their particular branches of study, it has also others who may profit by such help as is in the power of every practised hand to give them.

Therefore I purpose devoting my address this evening to some account of my own particular pursuit, much of which is applicable, to a large extent, to other branches of study in which the microscope takes an all-important part—viz., the collecting, growing or cultivation, and examination or display of microscopic aquatic life. So much invaluable information upon the first subject is given in numerous works at hand that I feel I shall have to repeat much that has been said before, and give little which can be called strictly original.

I have thought it strange that while marine creatures are sought regardless of cost or peril by means of very elaborate and skilfully-contrived appliances, dredging and sounding apparatus, steamers specially fitted out for cruises in dangerous parts of the ocean, zoological stations and expeditions arranged under the auspices of even a British Government, the living multitudes (fishes excepted) which inhabit our rivers, lakes, and ponds should be left to individual and usually very casual and unsystematic research. It is doubtless attributable to this cause, or neglect, that so many of the forms found in this country come to us rather as proofs of the faithful industry of observers in other countries than of our own original work and enterprise.

It is true that investigations in marine zoology are often associated with other matters of equally great scientific and commercial importance, and that the marvellous fauna of the ocean is vastly more grand and extensive; but, on the other hand, so many of us are destined to live in inland districts, and so keen is our appetite for an insight into the beginnings of life, that the tiny inhabitants of our ponds and streams should claim a much larger share of our thought than they do, for it is upon them that we have to rely chiefly for our acquaintance with those wondrous works of nature which are the foundation and key to the science of Biology. It sounds oddly enough that an expedition should go out for a few years' explorations in arctic, antarctic, and tropical seas, with every preparation for the capture and study of their faunæ by the first men of science, while our creatures at home should be left to the enthusiastic "Sir Thomas," who ties his bottle to the end of his stick or umbrella, and who may perhaps venture so far as to go over shoe-top in his endeavour to reach some desired spot, or capture some coveted creature. It is not because the knowledge of these creatures is of little importance, for we have oft-repeated evidence that a better acquaintance with the part they play in the economy of nature will be of the utmost value to us in our attempts to understand the principles of health and disease. I have felt ashamed that, with the exception of a few splendid works, such as "Allman on the Fresh-water Polyzoa," "Baird's Entomostraca," and some others, we have to rely chiefly upon foreign publications for descriptions of our own microscopic life. No wonder that so many of us looked forward with delight to the completion of that excellent work by our friend and member Saville Kent upon the Infusoria, preceded as it was by that of G. S. Brady upon the Copepoda, and another noble contribution to our knowledge, if not by our countryman at least in our language—I mean the splendid monograph of the Rhizopoda by Professor Leidy—a group of organisms of wonderful structural simplicity, and yet shown to be all sufficient to perform the functions of active life.

Many of the organisms there described are familiar to us, and probably nearly the whole will be found identical with those of our own locality; indeed, Mr. W. Archer, of Dublin, has already found many of them in Ireland. This opens up the interesting and difficult question of distribution, which I shall not attempt to discuss, but merely note the curious coincidence that *Anuræa longispina*, a rotifer of about one-fortieth of an inch in length, should have been found both here and in America at nearly the same time, associated, as it was in our case, with other organisms bearing spinous processes. I trust that that splendid group of creatures to which Anuræa belongs may soon have the same duty rendered it as has been done for the Infusoria, and that we may not have to wait long for a monograph or manual of the Rotatoria, a work which I believe is already in progress.

I confess to having paid perhaps too little heed to the advice upon collecting, which was at hand when I first sought after the minute mysteries of fresh-water life, preferring rather to work away with that enthusiasm which knows no obstacles and heeds no rebuffs when creatures new to me, and possibly new to science, were to be found, and in seeking them relied rather upon the knowledge gained by experience than any which might be gathered from books.

There appeared two ways open for systematic hunting, and much might be said in favour of both—that first adopted being the plan of naming the localities, and then taking care to place the gathering from each in bottles bearing a conspicuous number, little time being spent in actual examination on the spot. The contents afterwards were carefully scrutinised by the aid of the microscope, which should always be done on the same day, and good note made of the localities from which anything of special interest was derived.

This plan answers very well, and soon gives one considerable knowledge of the inhabitants of a number of habitats, but is open to the objection, especially where long journeys are made, that good gatherings may be taken of things of little interest, and small ones of what is most valuable, thereby wasting much time and possibly missing the opportunity of taking some specimens which are never again to be met with, an experience I have had many times.

The next method is the one I greatly prefer, and always adopt if there is time to carry it out, and that is to ascertain on the spot, as far as possible, what the gathering contains.

I fear many who think microscopic creatures altogether beyond recognition without the aid of a powerful instrument will regard this method as a most difficult one, and yet I believe most persons, especially our younger friends, of keen sight, may, with a little study and careful training, become able to identify creatures more minute than would at first seem possible, either with that splendid binocular arrangement, the eyes alone, or, at all events, by the help of a good pocket lens, and a suitable pocket trough, which is of equal importance.

Portable microscopes are made for this purpose, but I have never found the need of one for gatherings made so near home that they may be thoroughly examined the same day.

As an illustration, I may say that I always search my bottles, or rather flat trough, with a pocket lens, for Amœbæ, and usually find no difficulty in ascertaining their presence or absence by this means alone, and I may further note that it has been my pleasure on many occasions to help those who could not see one of these organisms with the aid of the microscope to see one without it, of course procuring favourable specimens, and placing them in the best possible light.

Choice of apparatus also requires thought, and as I intend that this may be of some real help to those who may follow me in pursuing this delightful study, I must ask the patience of those to whom it is already familiar in describing my own collecting case. It is a light leathern box, about 12in. × 6in. × 4½in., with smooth handle attached, having twelve or more thin wooden partitions inside arranged for holding a variety of bottles and other things necessary for the purpose.

When complete, it contains four bottles holding about four ounces each, one smaller with a screwed neck for attaching it readily to the pond-stick, and ten, or more, made from glass tubing about 3½in. long by ¾in. diameter, all being numbered and having corks attached by string.

Besides these, a ring net, made of fine French canvas—a material used by ladies, I am told, for the purpose of wool-work—a still finer net of muslin, which will slip over it easily, making the one screwed ring do for both, and being of great use when the specimens sought are too small for the coarser net. A cutting hook also, to screw to the stick; a small grapnel or four-pronged hook, made of soft copper wire, about as thick as a straw (or "No. 9, B.W.G."), cast together by means of lead or soft solder, with a few inches of brass chain attached, weighing about eight ounces altogether.

Then a plaited flaxen or cotton line, which will not gnarl when wet, of fifty or sixty yards in length, and sufficiently strong to stand a considerable pull, enough even to straighten the soft hook, and so set it free should it meet with wood or any hard substance in the water which renders it fast.

A little practice with this apparatus will enable one with a fairly strong arm to throw, or rather sling, it out and gather aquatic plants from a large area, fifty or sixty yards even from any favourable spot for "paying" out the line, where it will meet with no obstacles when running out.

Then a long test-tube, and one or two pipettes, a pair of long forceps, a flat trough, and a "condenser," or contrivance of some kind for filtering out the captures, complete the contents of my case under ordinary circumstances.

How much importance I attach to the use of proper apparatus may be gathered from the fact that I attribute the non-discovery of Leptodora before 1879, not to its non-existence in our locality, but to the want of a suitable net properly used, these creatures escaping through a net too rough, and being unnoticeable, owing to their extreme delicacy on the one hand, and the quantity of alga they are usually taken with on the other, when a net too fine in the mesh is used.

It is quite true that the first one I obtained from Olton reservoir was taken by dipping an inverted bottle to a considerable depth, and then by a quick turn allowing the water to rush in: but I have often repeated the experiment where these creatures are fairly abundant, and have usually failed to capture a single individual, when a few sweeps with a suitable net would make a good gathering.

Then, as to choice of localities. As you know, water only needs to be exposed to the air, with the addition, perhaps, of a little animal or vegetable matter, for a very short time to become charged with organisms of some kind, and the grand work of Dallinger and Drysdale alone shows of what deep interest even the earliest appearance of flagellate Infusoria is to the careful and skilful observer; but most of the larger and more beautiful forms require a more congenial habitat than this, and therefore those who wish to find and study them must search in spots where conditions are most favourable.

Now let us take a large pool or reservoir, where the use of a boat is out of the question, and see how we are to go about ascertaining what it will yield to our search. We first find out where we may best approach close to the water, and, taking a dip with our screw bottle, soon gain some knowledge about the creatures which may thus be gathered. At the same time we take particular note of the plants growing about the edge of the pool, so as to make sure as soon as possible whether the present water-line is fairly constant, or only very temporary, for we know it is useless searching aquatic plants for good finds unless they are submerged, if not permanently, at least for considerable periods of time.

Well, while I am writing this I have in my mind that elysium of microscopic life, the reservoir at Barnt Green, which, until a large area had been scoured by means of the before-mentioned hook and line, had been considered barren of anything of special interest.

It is certain that when the bottle only was dipped in near the side nothing of more than ordinary character was found; but when the hook was sent flying through the air, and a good bundle of weeds (*Polygonum amphibium*, I believe) was brought to shore from a distance of thirty or forty yards, and carefully examined, living treasures were found in perplexing abundance.

I need scarcely remind our members of the many splendid creatures which that locality yielded, the delight with which we looked upon that rare beauty *Zoothamnium arbuscula*, the lovely groups of rotifer life, *Lacinularia socialis*, the numerous species of Polyzoa, the interesting and typical creature *Dendrosoma radians*, and hosts of other things which gave a charm to our weekly meetings for a long time, and made us the justifiable envy of our less fortunate neighbours, who only heard of our good fortune, or perhaps got a specimen bottle from our friend Mr. Bolton.

Now I do not think it too much to say that this, like many other localities, had never been thoroughly searched before, and am quite sure that some of our neighbours who regard their districts as unfavourable for pond life may find riches within their reach quite as great if they will only adopt the same vigorous methods of seeking them.

In looking for specimens of microscopic aquatic life it is necessary to note carefully the conditions which prove most favourable to their existence, for it is certain that the larger our acquaintance with them the more sure are we of success, and the less likely are we to become tired of the pursuit before we have mastered its difficulties.

The water needs to be fairly still for most things, and I have found it most favourable when there is some clay and a fair quantity of vegetable matter in suspension; but a few creatures, as *Hydra vulgaris* and some species of Polyzoa, being voracious feeders, are usually most abundant where the water is in rapid motion, as at the flood-gates and outlets of pools, the weeds, woodwork, or stones in these parts being sometimes truly carpeted with these animals.

I generally avoid those ponds altogether where the water looks black and smells strongly of that curious alga Oscillatoria, interesting as it is, for I expect to find little else there, and if the situation is much exposed to the wind the quiet spots where the weeds grow pretty freely in deep water are to be sought in preference to all others.

It is quite true that in warm summer time a dip in any part is sure to yield something which will repay the search, but in winter or cold weather only the more sheltered spots are worth much attention, and so obvious does this seem that I should scarcely deem it worthy of mention, only that evidence is plentiful that it is often entirely overlooked even by those who are presumed to be fairly expert.

I have often felt amused—and the source of amusement is still open to us—at the many fanciful things which have been said about that delightful object for the microscope, *Volvox globator*. How is it, it is asked, that it is found in abundance one day and has entirely disappeared the next; and what becomes of it in winter? Does it assume some strange garb and pass unrecognised and unrecognisable in its disguise, or is its existence left to the so-called winter spores seen in the *Volvox aureus* of Ehrenberg, which are supposed to sink in the mud only to appear again with the coming sunshine?

Now I made Volvox my special exhibit so many winters at our Midland Institute Soirées that I became fairly ashamed to show it; and as it is a most difficult thing to keep in artificial aquaria for any considerable time, I had often to renew my stock from some natural source, which I was nearly always able to do, in summer or winter.

Whence, then, come all these mysteries about its appearance to-day and its disappearance to-morrow? Why, the fact is, many who search ponds for this and other free organisms do not take the necessary means to find out whether it is present or not, and unless a few dips suffice to secure specimens it is at once settled that the thing is not there.

The explanation is that Volvox is greatly stimulated by light and warmth, as is usually the case with plant life, and under these favourable influences it will not only increase at a great speed, but will roll through the water in every direction, so that the most hap-hazard dip with a bottle is sure to secure specimens; and I have many times seen it even covering the banks like a green scum where the water has receded and left it stranded, as we see marine objects on the sea-shore.

But in winter or times of extreme cold it makes its retreat from the "weather" side of the water, and is to be sought very near the bottom in some shallow part where the weeds not only give it shelter, but find it anchorage too ; and knowing these spots at my particular hunting-grounds, I have often stood upon the ice and, after breaking a hole with a hammer, dipped in my bottle or swept beneath with my canvas net and gathered it in any desirable quantity.

Of course it may happen that the particular patches of weeds among which it is snugly nestling are out of reach unless we are equipped with water-tight boots and prepared to risk their efficacy for keeping the feet dry ; but, though I do not wish to impress upon you that I think when it is once present it always remains so, I am sure a more thorough search will prove that the vagaries with which this organism is credited are only the fancies of the insufficiently persevering pond-hunter, and that there is no period of the year when it is not to be found.

If we make a sudden jump from the Vegetable to the Animal Kingdom, perhaps there are few creatures of more general interest and beauty than the thecated rotifers, Floscularia, Melicerta, Œcistes, etc., and a study of these indicates beyond a doubt that in active life they require a plentiful supply of decayed vegetable matter with which to build up their tiny structures, and, as I shall show you, I have made good use of this knowledge in collecting and keeping them afterwards.

Next to these, perhaps, should be placed that most beautiful of the free rotifers, *Notommata Brachionus*, which came to my hands in abundance in the following instructive way.

I was driving along a country road, with a keen eye for likely ditches or puddles, when I came to a heap of rubbish with just a small patch of water at its base not more than three inches deep in the wheel-ruts or holes made by the feet of cattle.

This I thought worth trying, and to my surprise found it contained *Pandorina morum*, and that charming rotifer before named.

Of course I took a good gathering. The only regret was that I felt sure that a few days without rain would entirely obliterate this very temporary habitat, and so it proved, for on going to the same place a week afterwards not a drop of water was to be seen there; indeed, so dry and hard had the ground become that I felt almost in doubt if I had not missed the exact spot. However, I was quite unwilling to return without a further effort to find this particular rotifer, as I felt quite sure this could be only a place where it had come by some extraordinary means, and I therefore resolved to re-search the only two ponds I knew in the immediate neighbourhood, which I did, entirely without success.

I then looked out for one of those useful but innocent auxiliaries to natural science, a farm labourer, and having got over the difficulty as to what was meant by a pond by explaining that it was a hole in a field where the cattle and sheep get water, received the information that there was a farmer who not only "kep a good dell o' cattle, but that he had a field up the bonk with a hole where they got water," and as far as he knew it never dried up.

To this "bonk" and this "hole" I made my way, the latter being quite out of view from even a few yards off, and you may guess my joy when I found that this was teeming with *Notommata Brachionus*, many of them loaded with their pendulous eggs, and that the pond also contained hosts of other good things, among which was that curious organism which afterwards proved to be *Rhipidodendron Huxleyi*.

I had not been there long when some sheep came near me, as I thought, to see what I was about, but which my bucolic guide explained in a less flattering way, telling me that they had come to drink, and here was a ready solution to the problem as to how the rotifers had got to the puddle on the roadside. These unintentional distributors of microscopic life would go to the pond and paddle in the water, and then readily carry either the eggs or the rotifers themselves upon their feet, and possibly leave some behind in the first puddle they passed through on their way.

Next to the desirability of successful search for microscopic fresh-water life comes the natural wish to be able to keep it, and, if I may use the word, cultivate it, and here let me put in an earnest plea for an extensive adoption of means to this end.

Like all lovers of this study, I have felt saddened to see the beautiful creatures, which I have perhaps been many miles to get, and which have afforded so much delight to myself and my friends, gradually dwindling and dying in the little glass bottles or, to them, fatal prisons in which I had placed them, and like others, too, have made many attempts to keep them in all the charming freshness of active life, as I found them in their natural habitats, in indoor aquaria.

Indeed it is a fact, as proved by my study of Dendrosoma alone, that if these things can by any means be kept in active life, it only needs careful observation to unfold their history with all its interest and absorbing attractiveness.

I have not wondered that many naturalists have from time to time spoken in high satisfaction of their success in maintaining and increasing their stock of such things as Melicerta and even Volvox, with other organisms of like interest, and am free to confess that my own indoor aquaria have assumed a very abnormal, not to say obstructive, growth, often proving successful, however, far beyond my expectation. But I have found that, with all ordinary care, the creatures and plants too are stimulated into such rapid changes that sooner or later they come to grief, if I may use that expressive sporting phrase, and that one needs to begin over and over again.

Now I was under considerable doubt as to whether a small pond constructed in my garden would be sufficiently successful to repay the somewhat heavy cost; whether the inevitable town surroundings of bricks and mortar, and the accompanying smoky and often dusty atmosphere would not overcome anything I might do in providing other more favourable conditions for the existence of these delicate organisms, and I am pleased, therefore, to be able to say that the plan has answered admirably, and that, in addition to the microscope and the complement of books which a student needs. I most earnestly commend all lovers of this study to acquire a garden-pond.

My own has not only furnished me with a grand supply of such things as Melicerta, Stephanoceros, several kinds of Floscules, Stentors, Hydra, both *viridis* and *vulgaris*, Amœbæ, innumerable infusoria and algæ, and some new or rare Desmids, as noted by Mr. Wills, but has given me, in addition, a constant supply of such rarities as *Œcistes umbella*, *Melicerta annulata* and *Tubicolaria naias*, with Tardigrada and free rotifers, etc., in abundance. In fact, I have only to complain of an *embarras de richesses*, and regret that want of time has prevented me doing as much with them as I could have wished.

Though the construction of a pond, or what in this case may be better understood if called a fountain basin without the fountain, is a simple matter, yet I know from experience that it is by no means certain to be made successful at the first attempt. Mine is a brick structure of about eight feet outside diameter, and about two feet six inches in depth, measured from the top edge to the base; the inside is made to slope at a good angle, which is very important. It stands about eighteen inches above the level of the surrounding ground, making nice sloping banks for about half its circumference, the inside being asphalted, which renders the whole perfectly water-tight. It has an outlet and a temporary means of supplying water, but the former is never required, and with the bountiful supply of rain we have had during the past few years, it has rarely been necessary to add any water whatever, occasionally just a little to keep up the level during any warm and dry period we may have happened to have, few of which have troubled us for a long time past.

The bottom and sides have a good layer of sandstone rubble with a little clay, furnishing innumerable nooks and crevices, where plants may root and animals may hide, no attempt whatever being made at architectural ornamentation. The rubble, however, is carried to and over the edge of the brickwork, which it completely hides, and is continued down the outside, making just a bit of ordinary garden rock-work, planted in the usual way with ferns, saxifrages, etc., forming in summer time a perfect maze of plant life, shading the water from some of the sun's rays, and affording shelter for the numerous reptiles which also find a home in or about the pond. The whole thing looks like a very humble attempt at imitation of one of those charming natural ponds one finds among the broken rocks on the rugged mountains of North Wales.

The botanical specimens here grown are very numerous, and were selected, I am afraid, on the principle adopted by the man who ascertained what were the best remedies for a cold, and then endeavoured to take the whole of them. Every plant which appeared particularly favourable to microscopic life has been introduced in some way or other, the result being that the place is crowded beyond all need with such plants as Chara, Nitella, Anacharis, Myriophyllum, Callitriche, Potamogeton, Lemna, etc., while the sides near the water are clothed with Caltha, Iris, Carex, and several mosses.

Besides the above there is a plentiful stock of a plant which has proved one of the most fruitful sources of some of the thecated rotifers. It is a grass which, my botanical friends inform me, is *Poa fluitans*, and wherever this is found growing in fairly deep water by the pond-hunter, I advise him to pull up some and carefully examine the innumerable small fibres which form its roots.

This plant seems to serve the tube-dwelling rotifers, as the reindeer does the Laplander, or the palm-tree the Asiatic or African, for it appears to find both food and clothing in abundance, and I have little doubt that the presence of the rare rotifers before named is due to this cause. One of my first finds among its roots was a Floscule, of extraordinary size and beauty. I think I exhibited some at our meetings having a length of over an eighth of an inch, and a Melicerta, if not an unrecorded variety, at least presenting many differences from the well-known *Melicerta ringens*; and, lastly, the two already-named rarities *Œcistes umbella* and *Tubicolaria naias*.

Of course the confervoid algæ grow much too fast in summer, and it is sometimes necessary to take some out carefully, disturbing the general arrangement as little as possible.

May I append to this an expression of my hearty desire that instead of the hap-hazard way in which suitable ponds for the preservation and growth of microscopic life are allowed to exist, efforts should be made to get those worthy of consideration protected, and influence used to establish new ones in places where they would cost nothing more than a trifling first outlay, and would prove centres of attraction to the microscopist, botanist, and others. How often have I heard it regretted that those famous preserves in Sutton Park known to many as "Webb's Stews," should have been so ruthlessly and needlessly destroyed, and yet these things could probably be replaced in the same grounds at a very trifling cost compared with the pleasure they would yield.

Even to those who do not pay any special attention to microscopic life I can strongly commend a garden pond, provided that art is used only as far as necessary for furnishing a perfectly water-tight basin, and that the rest is made as natural and wild as may be, for, besides the plants, the creatures of large size, as frogs, toads, water-tortoises, newts, snails, and insects afford so much interest to every lover of nature that the garden pond becomes a never-failing source of pleasure.

Having, I am afraid, somewhat wearied you upon the details of collecting and keeping or growing microscopic life, I will limit, as far as possible, my remarks upon the next point I have in view, namely, the methods of examination, or rather display; and in using the word "display" allow me to make all needful apology for adopting a term which would seem to place this study upon so unscientific a basis. So many of us are, however, engaged in the serious business of life, that opportunities for real research are few, but, though the examination of these organisms be only pursued for the pleasure it affords ourselves and our friends, it is scarcely possible for the observant follower to miss adding something, either directly or indirectly, to that monument of intelligent labour which we call Science.

Let me say at once that, with a boundless love for these beautiful creatures, I felt the growing conviction that they were worthy of my constant endeavours to find out means of displaying them in accordance with what I suppose I must call "high art." For in these days of æstheticism, when the love, and I might say the worship of the beautiful, if not of the ridiculous, has grown to a positive mania—when boys and girls, with only sixpence a-week to spend, will spend threepence or perhaps the whole of it in the purchase of flowers, and when artistic skill is brought to so great a perfection that it almost needs a pocket-lens to tell whether the bonnets of the ladies are decorated by the productions of the florist or the work of the artist—it is more obviously necessary than ever that the real works of nature should be put before us in the best possible manner, and this, with microscopic life, is only to be done by much practice and skill.

Take, for example, a thick trough containing Entomostraca and dirty water; show it with an unsuitable light and a bad instrument and every unfamiliar person will exclaim, "What a lot of horrid things," or something equally complimentary and equally true. But, on the other hand, take only a single Daphnia and place it tenderly in a drop of clean water between two thin plates of glass, throw upon it a flood of oblique light by means of a good instrument and apparatus, and that which before appeared as an almost loathsome deformity is now seen to be a living marvel of exquisite beauty, and exclamations of admiration take the place of those of disgust.

Take even a single rotifer, and endeavour by examination to make out all its wonderful details, and see what a splendid field for manipulative skill it will afford, and how truly worthy it is of the pains you have bestowed upon it

Every worker with the microscope has doubtless felt that the inherent defect of this instrument is that when high powers are used which will render the most minute and delicate features manifest the greater portion is necessarily out of focus, whilst if a low power is used in which this defect is much less obvious the details, which are of the greatest interest to the observer, are lost sight of. The obvious suggestion is, that the objects should invariably be placed in the thinnest possible space so as to offer the least needful obstruction to the object-glass on the one hand, and the light on the other; and perhaps, for many things, no apparatus is more simple and effective than the Wenham compressorium, which I have very constantly used.

My desire has ever been not only to see the beauties of microscopic life myself, but, so far as possible, to devise means of showing them to others, or of helping those who need assistance to see them and display them for themselves.

Perhaps I have made more experiments with that charming organism *Volvox globator* than with anything else, and the mention of some may be of value to others.

I directed my first attention to what may be called massing or crowding them together, getting them out of dirty into clean water, freeing them from other things which it was undesirable to show at the same time, and several methods succeeded very well.

Let us suppose that we have a jar with a good gathering of Volvox, and we wish to get them so thickly together that the whole field of the microscope may be filled with them, nothing being more beautiful as an object of display. The most natural way to attain this is by filtering them out, and for this purpose I have made some small metallic sieves, the mesh of which is not more than one-hundredth of an inch in breadth, such as the one I now have before me. This I place in a small shallow vessel, pouring the water not through, but outside the sieve, and then by means of a small syringe withdraw the water through this fine gauze, continuing the process until I get the Volvox at the bottom of the earthenware vessel as thickly together as I like. They may then be picked up by means of the syringe and placed in any quantity or density upon a slide or compressor, care being taken in showing them to allow only just sufficient depth between the top and bottom glasses to allow them to revolve freely through the water. The same result I have obtained by taking advantage of the effects of heat and cold upon these organisms. If they are freely distributed about the water in which they are stored it is only necessary to take some ice and lower the temperature of the water to bring most of them to the bottom, or if they are at the bottom, mixed with dirt as they often are, then to place the jar near the fire, and so stimulate them, and bring all that are living and fresh to the top, when they may be brought to one side of the vessel by directing upon it a bright light.

It is usually regarded as a difficult matter to see the cilia upon Volvox by even those familiar with the use of the microscope ; but these may be made so plain that the most inexperienced person may see them without the least trouble, provided that a strong light with the *yellow* rays unintercepted be used, and that sufficient obliquity be obtained by means of a paraboloid or other apparatus, using a compressor with a thin glass top and bottom, and just slightly flattening the largest of the spheres. The half-inch is best ; but when they are once seen and all things are properly arranged, there is no real difficulty in watching their flashings with a one-inch or even a two-inch object-glass.

Then take another of those perplexing objects, the Amœba, which is regarded as not only hard to find, but harder still to see, and let me say that the two difficulties resolve themselves into the latter one only, there being no trouble whatever in obtaining specimens.

As I have already said, I usually look for these either without any optical assistance at all or with nothing more than an ordinary pocket-lens, and that is generally quite sufficient. But of course it needs to be pointed out that these organisms vary greatly in size, and while some are more than one-tenth of an inch in diameter, others appear as mere specks even with an amplification of four or five hundred diameters, so that it is only the larger forms which may be picked out in the way described.

Then at first they seem particularly difficult to handle and isolate, being usually found so near the mud, or mixed with it; but a little study of the habits of these organisms shows a ready way to get over that difficulty.

Not being swimmers, though doubtless like the hydra they possess the power to rise or fall in the water, and have besides some slight means of free locomotion, they are usually found to attach themselves to anything with which they may come in contact, generally decayed weeds or mud, and it is only necessary to take advantage of this habit to obtain them quite free from everything else.

Take up some mud and water in which they are plentiful and fill a thin trough; lay it nearly or quite flat upon the stage of the microscope and allow it to remain there a few moments; then quietly empty out the mud and dirty water at one end while you replace it with clean at the other, and the Amœbæ will be found attached to the glass as clear as the noonday sun. Care only needs to be taken that the clean water shall replace the dirty without exposing the animals to the air or they will fall to pieces in countless granules, an experiment worth noting.

It requires but a little practice even to pick out of a trough, while under the one inch, any particular specimen, and place it by itself on a slip of glass or compressor, provided a very fine tube drawn out to the thinness of a hair at one end, and having an india-rubber teat with the aperture sealed at the other, is used for the purpose.

Here, again, black back-ground illumination, with a suitable power and binocular instrument, will demonstrate that the Amœba is not the bit of flat protoplasm it is usually supposed to be, but a creature having both breadth and depth, able to attach itself to the top glass by some of its pseudopodia while it is fixed to the bottom by others, being comparable, when seen in this way, to a piece of white coral.

What these mysterious forms of life are I do not pretend to say, whether independent organisms, or only stages in the development of other creatures; but I am certain about Dendrosoma being able to assume an amœboid condition, and, though I have little to support it, I have always thought that the new genus and species *Lithamœba discus*, as described by Professor Ray Lankester, which came from my aquaria, was a phase in the life-cycle of *Epistylis leucoa*.

Advantage may also be taken of the habits of many other creatures, if they are only known and studied, a bright light or a dead entomostracan often being sufficient to attract many organisms to a desired spot from which they may be readily picked up by means of a syringe or dipping-tube; but without even this, numbers of the most lovely rotifers will cluster together like so many bees, and if only the manipulator's eyes be trained to detect and recognise them, a great amount of delicate work, far beyond the most practised skill, or the best mechanical contrivance, is performed ready to our hand.

Those who have seen a group of the charming creatures, *Notommata Brachionus*, spinning their tiny threads, swinging, gambolling, and frolicking about in their aquatic revelry; or their little less beautiful allies, *Synchæta tremula*, need only be told that they arrange themselves in this manner just as though they knew they were required for exhibition.

The fixed rotifers, too, may generally be dealt with just as certainly, though in that case much longer time is required to carry the preparations out, for if they are found, as often happens, on such a plant as Anacharis (one of the worst, perhaps), they may usually be got to take to something else, such as Myriophyllum or the submerged leaves of Ranunculus, if these plants are kept in the pond or aquarium to which they are introduced.

The few illustrations here given are only intended as hints of what may be accomplished by everyone who earnestly makes the attempt, bearing in mind that, in examination for ourselves or display for others, it is always necessary to consider well what the prominent features are which we ought to see or show, and that we should never rest satisfied until we can render these perfectly clear and bright.

I do not know whether the electric light, as recently introduced for the illumination of microscopic objects, will be brought within our reach, or work any changes for the better if it should; but I am quite sure that the apparatus already to hand is capable of grand achievements if only used in the best way, and my hope is that these notes may help to stimulate others in their endeavours to accomplish this end.*

NOTE.

(Read at a previous Meeting.)

Volvox globator.—Is it a Hollow Sphere?

The question asked at the heading of this note is answered in the affirmative by so many competent observers that I should hesitate in submitting an opposite reply, did I not feel sure that it is easy for microscopical students to demonstrate for themselves the certainty that these charming little globes are not hollow, but solid.

Probably no microscopic organism has attracted, or deserves, more attention, or has been more fully discussed than *Volvox globator*. Each interesting feature in its structure and life-history, as far as they have been recognised, has again and again been studied, a variety of views upon most of its details being the result, and strange it seems that with so much careful observation, and so many often contested points, the idea of its being hollow has passed as so self-evident as scarcely to have been challenged.

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* Mr. Levick here remarked that he had mentioned one piece of apparatus which the members might not be able to purchase or make for themselves, and that was the fine metallic net. He had therefore brought a few, which he had much pleasure in placing at their disposal.—Ed.

Seen in the microscope in the perfect state, in all its living beauty, it most certainly does appear, as usually described, a "hollow pellucid globe," and a solution to the difficult problem as to the possible nature of the force which causes the young Volvoces to escape from the parent envelope with so much energy is by no means apparent.

As frequently happens, little accidents lead to the discovery of facts which otherwise seem out of one's reach, and a few years ago, when I made frequent collections of this organism, I gathered some containing the rotifer which is said to make Volvox its nest, *Notommata parasita* of Ehrenberg, and, while watching these little fellows in the home of their adoption, was surprised to see that they were eating something of sufficiently solid consistency to keep them in position in a part of the Volvox where, according to the hollow-sphere theory, there should be nothing to eat, or to bear their tiny weight. The rotifers usually made their way to the Volvoces within the parent, where they appeared to take up their quarters. The next thing noted was that, when Volvox was placed upon white blotting paper, which of course left them high and dry, they still retained a good deal of their rotundity, and became flattened much less than would be expected if they were really hollow.

However, a little experiment, which it is easy for everyone to try, shows that Volvox is without any cavity whatever, and that the perfectly transparent contents of the globe appear to possess little if any less firmness than the pellicle or membrane which forms its periphery. This may be shown by taking Volvox in good quantity and straining the water from them; by this means a little mass may be obtained. Let the Volvoces thus collected be taken up rather roughly by means of a syringe, and placed in water containing carmine or any fine solid matter. It will probably be found that some of the Volvoces have been broken, some perhaps even into fragments which still display the rolling motion. Now if a little care is used in examining the ruptured specimens it will be seen that the carmine adheres to any surface thus exposed, at once displaying the fact of its solid consistency. This is much more easily observed if the Volvoces are again strained off and placed in a compressor with a little clean water.

With this elucidation it is no longer difficult to understand how, as the young Volvoces continue their growth within the parent, there comes a time when the overstrained envelope bursts, and, as before remarked, they escape with so much energy. The manner and means of escape of the young is often seen in a gathering of mature specimens, especially if the weather is fine and warm, but this result may be brought about much sooner by the addition of a little carbolic acid, which will often cause nearly every one to burst within a very short space of time, a fact I have noted to my chagrin when mounting slides of this beautiful organism.

Solid is too strong a word, perhaps, to apply to matter which cannot be more than gelatinous, and is here used only in antagonism to the word *hollow*: but, if the spheres be stripped of their outer green covering, this envelope collapses, while the contents retain their spherical form, as is readily seen by the displacement of the carmine.

(Added April 3rd, 1883.)

Since I read this note, which necessarily caused much discussion at the time, it has been confirmed by several observers, and, as it has not been published, is introduced here.

I have tried the further experiment of freezing a mass of Volvox upon a slide, and with a sharp knife cutting some sections, which were found to retain the matter within the green envelope, and this internal matter, whatever it may be, proved to be sufficiently dense to support particles of carmine, dirt, or any other solid matter which lodged upon it.

The contents are so perfectly colourless that they are quite imperceptible in water, unless it be charged with suspended matter, and then only show their presence by displacing this matter from the space which they occupy themselves.

TWENTY-FOURTH ANNUAL REPORT

OF THE

BIRMINGHAM

NATURAL HISTORY AND MICROSCOPICAL SOCIETY,

READ AT THE

ANNUAL MEETING, HELD FEBRUARY 6TH, 1883.

The Committee have pleasure in reporting that the work of the Society has proceeded with regularity during the year 1882. The number of papers read has been somewhat smaller than in the previous year, but in interest and value they have certainly been equal to those which have been presented to the Society at any period of its history. The attendance has been somewhat below the average, a fact which may be perhaps attributed to certain circumstances in connection with the arrangements for the accommodation of the members at the Mason College, to which the attention of the Committee is being at present directed.

The Friday evening meetings ceased to be held after the first six months, as the attendance was not sufficient to justify their further continuance, and there was besides the fear that they helped still further to decrease the numbers of those who attended the Tuesday meetings.

The Annual Conversazione was again held in the Town Hall last year, and was perfectly satisfactory with regard to the quality and extent of the exhibition, but owing perhaps to the short notice which was given of the date on which it was held (November 13th) the attendance was below the average.

During the year there have been three Day Excursions—on Easter Monday to Cheltenham and Birdlip, on Whit Monday to Worcester and Holt Fleet, and on August 7th to Bewdley. There have also been Half-day Excursions to Nuneaton, Sutton Park, Earlswood, Aston and Witton Reservoirs, Water Orton, and Barnt Green.

No marine excursion took place last year. It is suggested that during the present year a second excursion shall be made to Oban, and this suggestion the Committee hope to see carried into effect.

The Meeting of the Midland Union of Natural History Societies for 1882 was held at Nottingham, and was as successful as any previous one. Several members of this Society attended, and were hospitably entertained by the Nottingham Societies. As the meeting this year will be held at Tamworth, it is hoped that a greater number will take advantage of the vicinity to Birmingham to attend what will no doubt be an interesting and instructive gathering.

The Committee have pleasure in recording that the Darwin Medal for the past year, assigned to the subject of Zoology, was awarded by the Council of the Union to two members of the Society, Professor A. Milnes Marshall and Mr. W. P. Marshall, for their report on the Pennatulida, read before this Society.

At the end of the year 1881 the Society numbered 384 members, including four honorary vice-presidents, thirty-one corresponding members, five life-members, and thirteen associates. Thirty-five new members have been elected. Three associates have passed the age fixed as the limit of their privilege, and thirty-eight members have either died or resigned. The total number of members and associates is now 378, showing a net decrease of six.

Fourteen Committee meetings and twelve Sub-committee meetings have been held, at which the attendance has been as follows:—

		Summoned.		Attended.
President	Mr. J. Levick	26	......	22
Vice-Presidents	Mr. T. H. Waller	18	......	11
	Mr. W. G. Blatch	18	......	8
Ex-Presidents	Mr. E. W. Badger	15	......	0
	Mr. W. P. Marshall	19	......	8
	Mr. W. Southall	16	......	7
	Mr. A. W. Wills	20	......	10
Treasurer	Mr. C. Pumphrey	21	......	17
Librarian	Mr. J. E. Bagnall	21	......	17
Curators	Mr. R. M. Lloyd	19	......	18
	Mr. H. Miller	17	......	13
Sec. Biol. Sect.	Mr. J. F. Goode	17	......	9
Sec. Geol. Sect.	Mr. A. H. Atkins	18	......	8
Hon. Secs.	Mr. J. Morley	26	......	26
	Mr. W. B. Grove	18	......	13
Elected Committee.				
Prof. T. W. Bridge		18	......	1
Mr. R. W. Chase		23	......	19
Mr. W. J. Harrison		21	......	9
Mr. W. R. Hughes		21	......	15
Mr. E. Tonks		19	......	6
Mr. S. Wilkins		17	......	10

During the year there have been twenty-four General Meetings, with an average attendance of 24·3, at which the ten following papers have been read:—

The Myxomycetes: Protozoa or Fungi?	W. B. Grove, B.A.
On the Ambulacra of the Earth-worm	John Anthony, M.D., F.R.C.P.
On Deep-Sea Fishes	T. W. Bridge, M.A., F.L.S.
General Report on the Dredging Operations at Oban, in July, 1881	J. F. Goode, and W. P. Marshall, M.I.C.E.
English Wheat	Rev. J. E. Vize, M.A.
On the Pennatulida obtained in the Oban Dredging Excursion, 1881—Part 3, *Virgularia mirabilis*	A. Milnes Marshall, M.A., D.Sc., and W. P. Marshall, M.I.C.E.

Nomad Fungi: The Reclassification of the Uredineæ	W. B. Grove, B.A.
Contributions towards a Knowledge of Midland Entomology:—Part I., Coleoptera	W. G. Blatch.
Notes on a Tour in America, Illustrated by Limelight Views ..	W. H. Wilkinson.
A Visit to Glen Clova and Callater ..	G. C. Druce, F.L.S.

The following Papers have been read at the meetings of the Biological Section:—

Ornithological Rambles in Perthshire	R. W. Chase.
Beavers and the Bute Beavery ..	Egbert de Hamel.
On the Pennatulida collected in the Oban Dredging Excursion, 1881—Part 2, *Pennatula phosphorea* ..	A. Milnes Marshall, M.A., D.Sc., and W. P. Marshall, M.I.C.E.
Notes on the Vegetation of Arable Land out of Cultivation	W. Southall, F.L.S.
On the Breaking of the Shropshire Meres	W. Phillips, F.L.S.
Trawling Excursions in the North Sea and Torbay, with special reference to our Sea Fish and Fisheries	Rev. W. Houghton, M.A., F.L.S.

The following Papers have been read at the meetings of the Geological Section:—

The Cambridge Coprolite Beds ..	F. T. S. Houghton, M.A., F.G.S.
The Occurrence of Carbonic Acid in Crystals	T. H. Waller, B.A., B.Sc.
The Quartzite Pebbles in the Drift ..	W. J. Harrison, F.G.S.
Basalt .. / Glaciation (*Communicated by Mr. W. R. Hughes.*)	T. Wright, M.D., F.R.S.
Recent Discoveries of Cambrian Rocks in the Midlands	C. Lapworth, F.G.S.
Views in Switzerland and Italy (illustrated by the oxyhydrogen lantern)	W. Pumphrey.

There have also been some general meetings devoted to the exhibition of special objects, and one to the discussion of the question, "Is Fertilisation necessary to the indefinite Perpetuation of a Species?" introduced by Mr. J. Morley.

The following were the chief specimens exhibited at the General and Sectional Meetings thoughout the year. Those marked with an asterisk (*) are new to the district.

Mr. A. H. Atkins, blood-red Sandstone, from Kinver Edge; and specimens of Lingulella, from the Hollybush Sandstone, Malvern Hills.

Dr. John Anthony, the dried skin of an Earth-worm, showing the ambulacral spines; and an extensive collection of pocket magnifiers, including Browning's platyscopic lens, and Steinheil's doublet.

Mr. J. E. Bagnall, (Phanerogams):—*Scirpus Savii*, from the Isle of Wight; *S. parvulus*, from Hants; *Vicia bithynica*, from Southend, Essex; *Anthemis tinctoria*, from Kent; *Isoëtes echinospora*, from Killarney; *Saxifraga Geum*, from co. Kerry; *Sisyrinchium Bermudianum*, from Galway; *Spiranthes gemmipara*, from Cork; *Aquilegia vulgaris*, from woods near Middleton; *Erica Watsoni* and *Pinguicula grandiflora*, from Cornwall; *Ammi majus*, *Echinospermum Lappula*, *Amaranthus retroflexus*, and *Malva borealis*, from near Kenilworth: **Œnanthe Lachenalii*, from near Stratford; *Rubus emersistylus*, (rare) from Haywoods: *Potamogeton densus* (rare), from Napton-on-the-Hill; *Carex ericetorum*, from roots obtained from the only British station; *Eriophorum gracile* and *Utricularia intermedia*, from the New Forest: *Artemisia norvegica*, (from the only European station) and *Myricaria germanica*, both from Norway, collected by Mr. J. B. Stone; a large number of maritime plants, collected at Hunstanton by Mr. R. W. Chase: *Escallonia rubra*, a native of South America, peculiar for its glandular leaves, stems, and flowers; and stigmas and pollen of the two forms of common primrose, showing a difference in character between the long and the short styles and in the size of the pollen. (Cryptogams, Mosses):—*Grimmia crinita*, from the only known British station near Hatton; *Archidium phascoides*, *Tetraplodon mnioides*, and *Phascum triquetrum*; *Tortula mucronata*, *T. latifolia*, *Anomodon viticulosus* (all rare), *Scleropodium caespitosum* (very rare), in fruit, and **Orthotrichum rivulare*, from Preston Bagot; **Dicranum fuscescens*, from Maxstoke; **Bryum cuspidatum*, from Fillongley; **Polytrichum commune* var. *perigoniale*, from Sutton Park; peristome (rare) of *Fontinalis minor*; *Dicranum montanum*, from four new Warwickshire stations; *Sphagnum fimbriatum* and *Fontinalis antipyretica*, from Maxstoke; *Cinclidotus aquaticus* (named by Schimper), and other mosses collected and named by Lorentz: *Bartramia Œderi*, *Encalypta procera*, and other mosses from the Engadine. (Hepaticæ):—*Riccia glauca*, from Erdington. (Fungi):—*Tricholoma stans*, *Cortinarius subferrugineus*, *Lactarius insulsus*, and *L. uvidus*, from Ludlow; *Lactarius hysginus* (rare), *L. vellereus*, **Cortinarius duracinus*, *Russula nigricans*, *R. fœtens*, *R. emetica*, *Hygrophorus eburneus* and *Clitocybe cyathiformis*, from Maxstoke; **Scleroderma Geaster*, *Sphærobolus stellatus* and *Clitocybe fragrans*, from New Park, Middleton; **Polyporus rufescens*, and **Hydnum scrobiculatum*, from Alveston Heath; *Hydnum repandum*, *Craterellus cornucopioides* (rare), **Lactarius pyrogalus*, **Cantharellus tubæformis*, **Ag. Candolleanus*, **Ag. spermaticus* and *Ag. fragrans*, from Shustoke; **Russula Queletii*, **Leptonia lamprocarpus*, and **Hygrophorus hypothejus*, from Coleshill; *Lenzites betulina* (rare), from Hartshill; *Ag. rhodopolius*, from Penns; and *Clitocybe brumalis*; *Boletus laricinus*, *B. scaber*, *Clitocybe pithyophila*, *Amanita muscaria* and *Cortinarius cinnamomeus*, from Middleton; specimens of the plants experimented upon by Mr. C. B. Plowright, in his trials of the heterœcism of the Uredines and a number of Fungi sent by Dr. M. C. Cooke, including *Clitocybe inversa*, *Collybia atrata*, *Cortinarius ochroleucus*, *C. incisus*, *Hygrophorus fornicatus*, *H. chlorophanus*, *Russula fellea*, and *Phlebia merismoides*. (Lichens):—**Ramalina fraxinea*, **R. fastigiata*, *Sticta Thouarsii*, *Physcia ciliaris*, *P. flavicans*, *Usnea florida*, and other rare lichens.

Mr. W. G. Blatch, a number of rare Coleoptera from Sutton

Park, including **Oxytelus fulvipes* (the only other British locality for which is Needwood Forest), **Leptusa fumida*, and **Phlœopora corticalis*; **Myrmecoxenus vaporariorum* (very rare), found near Birmingham; **Cryptocephalus coryli* and **C. punctiger* (both rare); **Hylecœtus dermestoides* (rare), found at Cannock Chase; **Dysdera Hombergii*, a spider of the Senoculina group, found near Knowle; and some fire-flies, *Lampyris splendidula*, from Switzerland, on behalf of Mr. C. Pumphrey.

Mr. T. Bolton, a parasitic growth on Closterium, believed to be a species of Pythium; a piece of sea-weed (Ceratium), on which were a great number of organisms, including Polyzoa, Mollusca, etc.; *Eolis Landsburgii*, from Bangor; *Lucernaria auricula*, from Swanage; *Bulbochate setigera*; **Floscularia regalis* (Hudson), new to science; and **F. ambigua*, both discovered by him near Birmingham; **F. coronetta*, since found near Dundee.

Mr. R. W. Chase, *Falco æsalon*, the Merlin, ♀ young; *Cinclus aquaticus*, the Dipper, young; *Tetrao urogallus*, the Capercailzie, ♂, ♀ and egg; *Tetrao tetrix*, the Black Grouse, egg; *Tetrix scoticus*, the Red Grouse, egg; *Charadrius pluvialis*, the Golden Plover, ♀ young and egg; *Ægialitis hiaticula*, the Ringed Plover, ♂ and egg; *Hæmatopus ostralegus*, the Oyster Catcher, ♂ young and egg; *Numenius arquata*, the Curlew, ♂ young and egg; *Tringoides hypoleucus*, the common Sandpiper, ♀; *Vanellus cristatus*, the Lapwing, young and egg; *Ampelis garrulus*, the Waxwing, ♀, killed at Rednall, near Bromsgrove; four specimens of a rare migrant, *Plectrophanes lapponica*, taken near Brighton; *Haliaëtus albicilla*, the White-tailed Eagle, shot at Stornoway, Isle of Lewis, the wings of which had a spread of seven feet; *Larus minutus*, the Little Gull, ♀, shot at Lancing, Sussex, and *Phalaropus fulicarius*, the Grey Phalarope, ♀, at Shoreham, Sussex, both in November, 1881; pied varieties of *Emberiza miliaria*, the common Bunting, *Linota cannabina*, the Linnet, *Turdus musicus*, the Thrush, all from Cambridgeshire; *Ruticilla tithys*, the Black Redstart, from near Brighton, and *R. phœnicina*, the common Redstart, from this neighbourhood; a double nest of *Fringilla cœlebs*, the Chaffinch, from Ely, no doubt constructed by two distinct birds, and each division of which contained eggs; plants from Hunstanton, Norfolk, including *Salicornia herbacea*, *Spiræa filipendula*, *Lychnis Githago*, and *Calamintha Acinos;* and fossils from the same neighbourhood, including part of the anther of *Cervus elaphus*, from Thornham.

Mr. F. H. Collins, *Bacillus tuberculosis*, the alleged germ of consumption, and *B. Anthracis*, the germ of splenic fever.

Mr. W. B. Grove, the following Fungi from this neighbourhood, (Hymenomycetes):— *Amanita vaginata*, from Warley and Sutton Park; *Lepiota cristata*, from Sutton; **L. carcharias*, from Water Orton; **Tricholoma humile*, from Sutton; *Clitocybe phyllophila*, from Water Orton; **C. inversa*, from Sutton; *Collybia radicata*, from Warley; **C. butyracea*, from Water Orton; *C. velutipes*, from Sutton; *Mycena galericulata*, from Sutton Park; **Pluteus nanus*, from Great Barr; **Pholiota squarrosa*, **Crepidotus mollis*, *Hypholoma sublateritium*, *Psathyra corrugis*, from Sutton; *Panæolus separatus*, from Great Barr; **Panæolus fimicola*, from Warley; *Coprinus micaceus*, from Sutton; **Bolbitius fragilis*, from Great Barr; **Hygrophorus hypothejus* and *H. pratensis*, from Water Orton; *H. virgineus*, from Sutton; *H. ceraceus*, from Sutton and Quinton; *H. coccineus*, from Water Orton; *H. conicus*, from Great Barr and Sutton; *H. psittacinus*, from Sutton and Quinton; *Panus stypticus*, from Great Barr; **Polyporus betulinus*, from Harborne; **P. sanguinolentus* and **P. annosus*, from Great Barr and Sutton; **P. obducens*, from Sutton; **P. spumeus* and **P. fumosus*, from Edgbaston (collected by Mr. C. E. Robinson); *Fistulina hepatica*, the Beef-steak fungus, from Sutton Park; *Corticium quercinum*, from Warley; *Clavaria vermiculata*, from Quinton; *Calocera cornea*, from Rotton Park Reservoir; **Tremella torta*, from Great Barr. (Gastromycetes):— *Geaster fimbriatus*, sent by Mr. W. H. Wilkinson, from Blockley, Oxon; *Cyathus vernicosus*, from Sutton, and *Crucibulum vulgare*, from Perry Barr. (Coniomycetes):— *Puccinia malvacearum*, from Alvechurch; *P. graminis*, from Barnt Green; **Urocystis pompholygodes* and *Coleosporium tussilaginis*, from Sutton; *Melampsora euphorbiæ*, from Sparkhill; *Œcidium urticæ*, from Alvechurch. (Hyphomycetes):—*Aspergillus glaucus*, on bread, to show the moniliform arrangement of the spores *in situ*: **Ægerita candida*, from Water Orton; **Epicoccum neglectum*, from Sparkhill; **Nematogonum aurantiacum* and **Polyactis fascicularis*, from Sutton; **Stysanus stemonitis* and **Dactylium roseum*, from Great Barr; *Trichoderma viride*, from Sutton and Sparkhill. (Ascomycetes):—**Chætomium elatum*, from Water Orton; *Eurotium herbariorum*; **Geoglossum glabrum*, from Sutton Park, (sent by Mr. W. H. Wilkinson); *Peziza granulata*, from Water Orton; **P. calycina*, from Sutton Park; *P. cinerea*, *P. fusarioides*, and **Helotium pallescens*, from Sutton; **Ascobolus minutissimus*, Boud., (new to Britain), on cow-dung, from Water Orton; *Epichloë typhina*, from Hampton; **Hypomyces aurantius*, **Nectria peziza* and **N. sanguinea*, from Sutton; *N. coccinea*, from Great Barr; *Hypoxylon concentricum* and *H. coccineum*, from Sutton; **Diatrype disciformis*, from Sutton; *D. stigma*, from Wylde Green and Sutton; **Melanconis stilbostoma*, from Edgbaston; * *Valsa aglæostoma* and **Sphæria orina*, from Sutton; **Sphærella rumicis*, from Harborne. (Myxomycetes):—**Physarum cinereum*, from Sutton; **P. sinuosum*. from Sutton Park; **Craterium pedunculatum*, from Olton; **C. minutum*, from Water Orton; **C. leucocephalum*, from Sutton; *Tilmadoche nutans*, and **T. mutabilis*, from Sutton; **Leocarpus fragilis*, from Sutton Park; *Fuligo varians*, from Edgbaston (found by Mr. C. E. Robinson); **Didymium squamulosum*, var. *costatum*, from Oscott; **Chondrioderma Michelii*, from Water Orton; *Spumaria alba*, *Stemonitis fusca* and **Comatricha Friesiana*, from Sutton; **Enerthenema papillata* (Pers.), *E. elegans*, Bowman, *not* Cooke, a very rare and curious species, on old boards, at the Crystal Palace Gardens, Sutton; **Trichia fallax*, **T. varia* and **T. nigripes*, from Sutton; **Prototrichia flagellifera* (very rare), from Sutton; **Hemiarcyria rubiformis*, *Arcyria punicea*, **A. cinerea*, **A. incarnata*, *Lycogala epidendron* and **Perichæna corticalis*, all from Sutton.—Also *Œcidium violæ*, *Œ. saniculæ*, *Uromyces ficariæ* and *Uredo potentillarum* found during the Cheltenham excursion; *Puccinia lychnidearum* from Holt Fleet;

Erysiphe Linkii, *Stigmatea Robertiani*, *Puccinia compositarum* and *Uromyces fabæ*, from Flintshire; *Corticium cæruleum*, sent by Dr. G. C. T. Schwarz, from Pembrokeshire; *C. sanguineum*, in the imperfect mycelial stage, sent by Mr. W. Phillips, from Shifnal, Salop; and other species from Messrs. Phillips, Plowright, and Soppitt.

Mr. W. J. Harrison, slides, diagrams, and models illustrating the modes of teaching human physiology; fine specimens of pseudomorphs of salt crystals from the Red Marl at Yardley; galena in Silurian limestone; coal showing "slickensides," from Dudley; *Monograpsus Salweyi*, from Walsall; dolerite and pitch-stone, from Scotland.

Mr. W. J. Harrison, jun., a specimen of *Lingula Lesueurii*, in a quartzite pebble, from Billesley Lane, Sparkbrook.

Mr. Geo. Heaton, specimens of seeds of tropical plants, etc., washed by the Gulf Stream to the coast of Donegal, N.W. of Ireland.

Mr. W. R. Hughes, *Ceterach officinarum*, *Asplenium trichomanes*, *Cotyledon umbilicus*, *Linaria cymbalaria*, *Erodium maritimum*, and *Saxifraga tridactylites*, from Brixham; *Gnaphalium leontopodium* (the Edelweiss), from Alp Ota, Engadine, 8,000ft. above the sea level; *Chrysanthemum segetum* (corn marigold), from a field near Christchurch, Hants, showing bifurcation of peduncle and coalescence of two capitula; *Asterina gibbosa*, an abnormal six-rayed form; and a wing of *Empusa gongylodes*, the praying mantis or walking leaf insect, from Wangaratta, Victoria, Australia.

Mr. F. Iles, *Nais digitata*, also some drawings of the same, showing the curious tentacles of the anal extremity.

Mr. J. Levick, *Œcistes umbella*, *Tubicolaria naias*, *Melicerta ringens*, *Lophopus crystallinus*, *Stephanoceros Eichhornii*, *Leptodora hyalina* (from the Warwick Canal, at Solihull), *Actinophrys viridis*, *Nassula ornata*, *Trachelius ovum*, *Bursaria leucas*, and *Cohnia roseo-persicina*; also forty-eight drawings of microscopic objects by Mr. E. T. Draper, F.R.S.

Mr. R. M. Lloyd, *Coprinus micaceus*, from his fern-case; *Vertigo moulinsiana*, from near Hitchin, Herts.

Mr. J. Madison, a white variety of *Succinea putris*, and *Limnæa peregra* var. *ovata*, which had formed an additional interior lip.

Professor A. M. Marshall and Mr. W. P. Marshall, many specimens and preparations of *Pennatula phosphorea* and *Virgularia mirabilis*.

Mr. C. A. Matley, a collection of fossiliferous quartzite pebbles, from the Drift, near Birmingham, containing *Orthis Budleighensis*, *Lingula Lesueurii*, Strophomena, and a trilobite tail; also quartzite pebbles, from the Bunter Conglomerate, at Great Barr, containing worm-borings of *Trachyderma serrata*.

Mr. H. Miller, *Lacinularia socialis*, from Welshpool.

Mr. J. Morley, *Pyrola minor*, from Scotland; *Orobanche hederæ*, from Conway Castle; *Hymenophyllum Wilsoni*, crested, from North Wales; *Polystichum angulare, proliferum*: *Draparnaldia glomerata*: *Stigeoclonium protensum*, from Barnt Green; *Apiocystis Brauniana*, from Sutton Park: *Spirotænia condensata*: *Micrasterias crenata*, showing a new, only partly developed segment: *Mesocarpus scalaris*, *Batrachospermum stagnale* and *B. vagum*, from North Wales; *Raphidia viridis*, var. *marginata*, from Earlswood, the head of *Vespa vulgaris*, mounted without pressure, by Mr. F. Enock; and Swift's College Microscope.

Mr. C. Pumphrey, *Actinophrys sol*, and a wild specimen of *Cardamine pratensis*, *flore pleno*.

Mr. J. Rabone, the Lump Fish, *Cyclopterus lumpus*, caught at Tenby; and an abnormal proliferous rose, the centre of which was metamorphosed into three or four distinct but undeveloped branches, each bearing many rose buds.

Mr. W. Southall, *Allium vineale*, and *Euphorbia Cyparissias*, with proliferous growth; blocks of slate, from Wales, bleached superficially through lying in a peat bog.

Mr. E. Wagstaff, *Cosmarium Botrytis*, in conjugation, from Quinton; *Eremosphæra viridis*, from Sutton Park; *Dendrosoma radians*, from near Harborne; *Lophopus crystallinus*, from near Halesowen; *Synura Uvella*, from Northfield; *Fredericella Sultana*, from Harborne; and *Sarcina ventriculi*, from the human stomach.

Mr. T. H. Waller, microscopical sections of Pre-Cambrian Rock, from Caldecott, near Nuneaton.

Mr. S. Walliker, *Polyporus nigricans*, the black-hoof polyporus, from Vossevanger, Norway; and dried flowers, ferns, etc., with the natural colours preserved, mounted on cards by Sisters of Mercy at Damascus.

Mr. S. Wilkins, *Merulius lacrymans*, the "dry-rot;" *Prunus spinosa*, the Blackthorn, in bloom, from Dorset (March 14th); also the imago of a large dragon-fly (*Æschna affinis*) ♀, reared in a small aquarium.

Mr. W. H. Wilkinson, *Cornus mascula*, the Austrian cherry; *Dædalea quercina* from Clent; and *Peziza aurantia*, from Solihull.

Mr. A. W. Wills, *Apiocystis Brauniana*, *Hydrurus Ducluzelii*, *Hormospora mutabilis*, *Glœocapsa sanguinea*, *Eremosphæra viridis*, and other Palmellaceæ; a slide of Desmidieæ, containing more than fifty distinct species, many new, from Capel Curig; Diatomaceæ from Chester town-water, and from the Leicester filter-beds.

J. MORLEY,
W. B. GROVE, B.A. } Hon. Secretaries.

BIOLOGICAL SECTION.

Twelve meetings have been held during the year, under the presidency of the Chairman, Mr. A. W. Wills, the average attendance at which has been 23, showing a decrease compared with last year, which it is difficult to explain.

Six papers have been read, the titles of which will be found on page xxix.

Some good work has been done and a large number of specimens have been exhibited in all branches, many of a most interesting character, the only regret being that the time at our disposal has often been too short to allow of more than a cursory examination.

On several evenings the whole of the time might have been both profitably and agreeably spent in the examination and discussion of a few out of the many specimens exhibited.

At a sub-sectional meeting, Mr. J. E. Bagnall read a paper on the genus Fissidens, illustrated by specimens.

It is to be hoped that the facilities offered will induce members to take a more active part in the proceedings, and that the work of the Section will continue to increase both in usefulness and importance.

JOHN F. GOODE, Sec. Biological Section.

GEOLOGICAL SECTION.

Eleven meetings of this Section have been held during the past year, with an average attendance of 26.

Seven papers have been read, the titles of which will be found on page xxix.

In the early part of the year sub-sectional meetings were held on Friday evenings, at which the following subjects were discussed :—

Barton Clay Fossils and Classification of the Eocene Formation ..	A. H. Atkins, B.Sc.
Geology of the Isle of Wight ..	Alfred Hill, M.D.
How to Copy and Exhibit Geological Views with the Sciopticon ..	Alfred Hill, M.D.

One specially Geological Excursion has been made to the newly discovered Cambrian Rocks at Nuneaton, under the guidance of Mr. W. J. Harrison, F.G.S.

A. H. ATKINS, B.Sc., Hon. Sec.

THE LIBRARIAN'S REPORT.

The Librarian is not able to give a favourable report of the Library; he finds several works of value missing from the bookshelves which have not been recorded in the "book kept for that purpose." He would respectfully call the attention of members to Rule I. of the "Rules of the Library."*

The following books are missing from the Library, without any record of their being taken out:—

Fossorial Hymenoptera, Shuckard.
Geodephaga Britannica.
British Spiders, Staveley.
Naturalist's Library; several volumes.
Botanist's Guide to the County of Warwick, Perry.

He has also to regret that Rule V. of the same rules has been sadly neglected this year.†

The issue of books has been as follows:—Botany, 60; Conchology, 17; Entomology, 17; Geology, 30; Microscopy, 48; Zoology, 36; Miscellaneous, 108; total, 306; a decrease of 104 as compared with last year.

During the past year the Committee have authorised the purchase of the following Works:—

Voyage of the Vega, Nordenskiold, 2 vols., 8vo., 1881.
The Cat, St. George Mivart, 1 vol., 8vo., 1881.
Report of the Challenger, Zoology, vol. iv., 4to., 1882.
Notes by a Naturalist on the Challenger, 1 vol., 8vo., 1879.
Zoological Record, vols. 15, 16, 17, 8vo., 1878-80.
Ants, Bees, and Wasps, Lubbock, 1 vol., 8vo., 1882.
Animal Intelligence, Romanes, 1 vol., 8vo., 1882.

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* Rule I.—"Any member wishing to borrow a book must signify his or her wish to the Librarian, who shall enter the name of such member, the particulars of such book, and the dates on which it was lent and returned, in a book kept for the purpose."

† Rule V.—"For the fortnight in the year next before the Annual Meeting the circulation of books shall be discontinued, for the purpose of enabling the Committee to ascertain the state of the Library. All books shall be returned on or before the first Tuesday of that fortnight, and any member neglecting to comply with this rule shall be fined one shilling."

American Ornithological Biography, 2 vols., 8vo., 1831.
British Insects, Staveley, 1 vol., 12mo., 1871.
Catalogue of Worms in the British Museum, Johnstone, 1 vol., 8vo.
Science and Culture, Huxley, 1 vol., 8vo., 1881.
Handbook of British Fungi, Cooke, 2 vols., 8vo., 1871.
Physical Geology, Green, 1 vol., 8vo., 1882.
International Scientists' Directory, Cassino, 8vo., 1882.
British Moss-Flora, R. Braithwaite, parts iv.—vi.
Illustrations of British Fungi, Cooke, parts vii.—x.
Manual of the Infusoria, Saville Kent, part vi.
Ray Society's vol. for 1882.
Palæontographical Society's vol. for 1882.
Science Gossip, 1882.
Journal of Botany, 1882.
Nature, 1882.
Quarterly Journal of Microscopical Science, 1882.
Midland Naturalist, 1882.
Annals of Natural History, 1882.
Zoologist, 1882.
Entomologist, 1882.
Entomologists' Monthly Magazine, 1882.
Geological Magazine, 1882.

The following have been presented :—

The Flora of the Clent and Hagley Hills, Wm. Mathews, M.A., by the Author.

Physiology and Pathology of the Blood, R. Norris, M.D., by the Author.

Report on the Oban Pennatulida, Professor A. Milnes Marshall, M.A., M.D., D.Sc., and W. P. Marshall, M.I.C.E., by the Authors.

On a New Species of Star-fish, from the Forest Marble, Wilts, Dr. Thos. Wright, F.R.S. ..
On a New Species of Brittle-star, from the Coral Rag of Weymouth, Dr. Thos. Wright, F.R.S. .. ..
On a New Astacomorphous Crustacean, from the Middle Coral Reef of Leckhampton Hill, Dr. Thos. Wright, F.R.S. .. ..
} By the Author.

On the Quartzite Pebbles, contained in the Drift and in the Triassic Strata of England ; and on their derivation from an ancient Land Barrier in Central England, W. J. Harrison, F.G.S., by the Author.

Old Faiths in a new light, Newman Smyth,
Geological Record for 1878. .. .. ..
} by Mr. E. W. Badger.

Report of the British Association for 1880, by Mr. C. Pumphrey.

Northern Microscopist, by the Editor, Mr. G. E. Davis.

Micro-Fungi, T. Brittain, by Mr. W. B. Grove.

Geology of Wisconsin, vol. 3, United States Survey, by the State Legislature.

Geological Survey of the Territories, vol. xii., by the Washington Government.

The Annual Report and three numbers of the Bulletin of the American Museum of Natural History, by the Trustees.

Presented by the respective Societies:—

Proceedings of the Natural History Society of Glasgow.

Proceedings of Birmingham Philosophical Society.

Transactions of the Epping Forest Naturalists' Field Club.

Report of the Leicester Literary and Philosophical Society.

Report of the Warwickshire Natural History and Archæological Society.

Abstract of the Proceedings and Transactions of the Bedfordshire Natural History Society, 1877-81.

Journal of the Northamptonshire Natural History Society and Field Club, parts 9-12.

J. E. BAGNALL, Hon. Librarian.

THE CURATORS' REPORT.

The Curators report that the microscopes are in the same state as they were at the time of their last report. They would urgently request the Committee to sanction the purchase of some lamps of a better kind than those which are now in use, as those are very dirty and troublesome, and to some extent dangerous.

The following presents have been made to the Society:— A collection of ninety dried specimens of Fungi, many new or rare, by Mr. C. B. Plowright; and a collection of fossil Hampshire shells, by Mr. B. Dain-Hopwood, as executor of Mr. C. Dain.

R. M. LLOYD, }
H. MILLER, } Hon. Curators.

Honorary Vice-Presidents:

T. SPENCER COBBOLD, M.D., F.R.S.
T. H. HUXLEY, LL.D., F.R.S.
CHARLES CARDALE BABINGTON, M.A., F.R.S.
HERBERT SPENCER.

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President: T. H. WALLER, B.A., B.Sc.

Vice-Presidents:
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Ex-Presidents (who are Vice-Presidents):
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CHARLES PUMPHREY.

Librarian:
JAMES E. BAGNALL.

Curators:
R. M. LLOYD AND H. MILLER.

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J. F. GOODE.

Secretary of Geological Section:
A. H. ATKINS, B.Sc.

Secretary of Sociological Section:
A. HAYES, B.A.

Honorary Secretaries:
JOHN MORLEY AND W. B. GROVE, B.A.

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W. J. HARRISON, F.G.S.
W. P. MARSHALL, M.I.C.E.
EDMUND TONKS, B.C.L.
SILVANUS WILKINS.
W. H. WILKINSON.

LIST OF THE MEMBERS

OF THE

BIRMINGHAM

Natural History and Microscopical Society,

JANUARY, 1883.

Those Members whose names are marked with (P) have been Presidents of the Society: those with (L) are Life Members; those with (C) are Corresponding Members: those with (*) are Guinea Subscribers; and those with (†) are Subscribers to the Apparatus and Library Fund.

To prevent the recurrence of a frequent misunderstanding, Members are reminded that their names are retained on the Society's books and their Subscriptions considered due until notice of resignation has been given to one of the Honorary Secretaries, in writing, according to Laws IV. and VI.

Name.	Address.
Abrahall, J.	2, Copely Hill, Gravelly Hill.
Adams, J.	Highfield Road, Harborne.
Albright, G. S., B.A.	Mariemont, Edgbaston.
Allday, Edmund	Park Road, Solihull.
Allday, John	The Oaks, Handsworth Wood.
Allday, William	330, Coventry Road, Birmingham.
Allen, W. S.	35, Waterloo Street.
Allport, Samuel, F.G.S. *(P)* ..	The Mason College.
Allport, S. B.	Whittall Street.
Anderton, J.	99, Suffolk Street.
†Anthony, John, M.D., F.R.C.P., F.R.M.S.	Greenfield Terrace, Edgbaston.
Antrobus, Alfred	Old Chester Road, Erdington.
Antrobus, P.	Church Hill, Handsworth.
Atkins, A. H., B.Sc.	King Edward's School.
Atkins, E.	Woodside, Handsworth Wood.
Austin, Josiah	Nechells House, Nechells.
Avery, Alderman, J.P.	Church Road.

Babington, C. C., M.A., F.R.S. (*Hon. V.P.*)	Cambridge.
Badger, A. Bernard	Oxford Road, Moseley.
†Badger, E. W. (*P*)	Office of *Midland Counties Herald*.
Badger, E. W., jun., M.A. ..	Oxford Road, Moseley.
Bagnall, Jas. E.	84, Witton Road.
Bailey, T. H.	Perry Pont, Perry Barr.
Bain, Rev. W. J.	Bridport, Dorset.
Baker, Bernard	Bellefield, Winson Green Road.
Baker, Harold	101, Gough Road, Edgbaston.
Barclay, Thomas	Moseley Road.
Barratt, J. O. W., B.Sc... ..	Exeter Row.
Bartleet, R. S., J.P.	The Shrubbery, Redditch.
Barwell, Chas.	Stockfield, Tysley.
Baxter, J. H.	15, Alston Street, Ladywood.
Beale, Dr. L., F.R.M.S. (*C*) ..	61, Grosvenor Street, London, W.
Bellingham, B.	205, Wolverhampton Street, Dudley.
Berkeley, Rev. M. J., M.A., F.R.S., F.L.S. (*C*)	Sibbertoft, Market Harborough.
Betteridge, J.	36, Suffolk Srreet.
Bevan, Rev. J. O.	72, Beaufort Road.
Birkmire, T.	107, Albert Road.
Blakemore, J.	Oban House, Ladywood Lane.
Bland, T. F.	High Street, Stourbridge.
Blatch, W. G.	Albert Villa, Green Lane.
Boeddicker, G. A.	Ethel Road, Harborne.
Bolton, Thomas, F.R.M.S. ..	57, Newhall Street.
†Bowater, W. H.	410, Lodge Road.
Boyden, Rev. H.	Pershore Road.
Braendlin, F. A.	Oakfield, near Knowle Station.
†Bragge, W., F.S.A.	59, Hall Road, Handsworth.
Brain, R. T.	234, Lozells Road, Handsworth.
Braithwaite, Dr. (*C*)	The Ferns, Clapham Rise, S.W.
Bridge, Professor T. W., M.A. ..	The Mason College.
Brittain, H.	Alston Street, Ladywood.
Brittain, Henry	George Street West.
Brodie, Rev. P. B., M.A. (*C*) ..	Rowington, Warwick.
Brown, Wm.	Waterloo Street.
Browne, Montagu, F.Z.S. ..	Leicester Museum.
Burgess, J. Tom, F.S.A. (*C*) ..	Bath Villa, Worcester.
Burman, R. H.	Lionel Street.

Caldwell, George	31, Worcester Street.
Callaway, C., D.Sc., F.G.S. (*C*)	Wellington, Salop.
Carter, H. J., F.R.S. (*C*) ..	Budleigh Salterton, Devon.
Cashmore, G. T.	11, Albert Road, Handsworth.
Caswell, C. B., F.I.C.	13, George Road, Edgbaston.
Chase, Robert	Great Barr.
†Chase, R. W.	2, Edgbaston Road, Edgbaston.
Chamberlain, Henry John ..	Kenilworth Place, Francis Road.
Chamberlain, R.	Westbourne Road, Edgbaston.
Chavasse, T. F., F.R.C.S. ..	24, Temple Row.
Chittey, E. J.	39, Bennett's Hill.
Clarke, Ann E., M.D.	Hospital for Women, Spark Hill.
Clarke, J. B.	Henley Lodge, Handsworth.
Clarke, T.	7, Trafalgar Road, Moseley.
Clayton, F. C., Councillor ..	18, St. James Road.
Cobbold, T. Spencer, M.D., F.R.S. (*Hon. V.P.*)	74, Portsdown Road, Maida Hill, London, W.
Collens, E...	Holly Lane, Erdington.
Collett, Harvey	West Bromwich.
Collier, J.	127, Rann Street, Ladywood.
Collins, F. H., F.L.S.	Church Field, Edgbaston.
Collins, G.	Oak Tree Cottage, Prospect Road, Moseley.
Collins, J. T.	Church Field, Edgbaston.
Cooksey, J. H.	West Bromwich.
†Cotterell, Wm., F.R.A.S. ..	17, Park Street, Walsall.
Cotton, I. J.	10, Great King Street, Hockley.
Cotton, J. W., F.G.S.	Exdale, near Coventry.
Cottrell, J...	176, Ashted Row.
Cox, W. H..	85, Rann Street, Ladywood.
Cresswell, A. N.	2, York Road, Edgbaston.
Crofts, George	The Cedars, Trafalgar Road.
Crompton, Henry D.	Beaufort Road, Edgbaston.
Crosskey, Rev. H. W., LL.D., F.G.S. (*P*)	28, George Road, Edgbaston.
Cumberland, T.	Dorset House, Harborne.
Dallinger, Rev. W. H. (*C*) ..	Wesley College, Sheffield.
Davis, Geo. E. (*L*)	The Willows, Fallowfield, Manchester.
†Deane, Rev. G., D.Sc. (*P*) ..	Spring Hill College, Moseley.
Derry, F., F.R.G.S.	31, Upper Hockley Street.
Druce, G. C., F.L.S. (*C*).. ..	High Street, Oxford.
Dugard, William	Lower Loveday Street.

Duignan, W. H.	Walsall.
†Dussault, A. L.	4, Augusta Road, Moseley.
Edmonds, John	General Cemetery.
Enock, F. (*C*)	Ferndale, Bath Road, Woking Station Surrey.
Evett, James	The Elms, Handsworth.
Fletcher, Dr. Bell (*L*)	7, Waterloo Street.
Ford, William Henry	Beaumont Terrace, Merridale, Wolverhampton.
Forrest, H. E., F.R.M.S. ..	8, Wyle Cop, Shrewsbury.
Fowke, F. (*C*)	Thatched House Club, St. James's Street London.
Francis, Mrs.	71, Wheeley's Road.
Franklin, C. E.	31, Suffolk Street.
Fraser, Dr. J. (*C*)..	Chapel Ash, Wolverhampton.
Fretton, W. G., F.S.A. (*C*) ..	Coventry.
†Fry, Henry A.	117, Gough Road, Edgbaston.
Gardner, J. B.	Priestley Road.
Gere, E. W.	Sandhurst Villa, Willes Terrace, Leamington
Gibbins, John	13, Arthur Road, Edgbaston.
†Gibbons, W. P.	Athol House, Edgbaston.
Gibson, A. H.	39, Bennett's Hill.
Glainville, B. J. (*C*)	Albany Museum, Grahamstown, South Africa.
†Goode, A. C.	Elmsley, Greenhill Road, Moseley.
†Goode, J. F.	The Moors, Church Lane, Handsworth.
Goode, Miss	34, Frederick Road.
†Graham, Walter, F.R.M.S. (*P*)	Ludgate Hill.
Grant, William T.	The General Hospital, Birmingham.
Greatheed, W.	Coverdale House, Hunter's Lane.
Greenway, J. F.	28, Wheeley's Road.
Griffiths, A. H.	Thornbury, Woodbourne Road, Edgbaston.
Grove, H. C.	Church Road, Harborne.
Grove, W. B., B.A.	269, St. Vincent Street, Ladywood.
Grubb, J.	Beaufort Road.
Hadley, F...	Hamstead Lodge, Handsworth.
Hadley, Miss A.	Hamstead Lodge, Handsworth.
Hadley, Phillip	41, Beaufort Road.
Hale, W.	King's Norton.
Hall, A.	Edith Villa, Albert Road.
Hamel, E. de (*C*)	Tamworth.

Handley, E.	Hendra, Church Road, Edgbaston.
†Harcourt, Charles	Maney, Sutton Coldfield.
Hardiker, W. A.	Albion House, Rookery Road, Handsworth.
†Harrison, W. J., F.G.S... ..	365, Lodge Road.
Harrold, William	188, Bristol Road.
Hassall, T. H.	Balmain House, Trafalgar Road, Moseley.
Hatton, T. S.	Waterloo Road South, Wolverhampton.
Heaton, James	Union Passage.
Heaton, George, J.P.	Church Hill, Handsworth.
Heaton, Mrs. George	Church Hill, Handsworth.
*Heaton, Harry	Harborne House, Harborne.
Heaton, Alderman, J.P. ..	Courtlands, Edgbaston.
Hill, Alfred, M.D., F.C.S. ..	Birmingham.
†Hill, A. J., F.R.M.S.	Leamington.
†Hill, Frederick	Park Street.
Hinds, James, M.B. (*C*) (*P*) ..	Halstead, Essex.
Hinks, T.	Buckingham Street.
Hobkirk, C. P. (*C*)	7, Arthur Street, Fitzwilliam Street, Huddersfield.
Hodgkinson, W. L.	Norwood House, Erdington.
Holbeche, R. A.	21, Bennett's Hill.
Hookham, George, M.A. ..	Trafalgar Road, Moseley.
Hooper, D...	98, Moseley Road.
Hooper, T...	Wylde Green.
Hopkins, A. N.	110, Bristol Road.
†Houghton, F. T. S., B.A. ..	313, Moseley Road.
Howes, Henry	Bristol Street.
Hughes, J...	York Street, Harborne.
Hughes, W. R., F.L.S. (*P*) ..	Wood House, Handsworth Wood.
Hughes, Mrs. W. R.	Wood House, Handsworth Wood.
Hullett, Alfred	Willenhall.
Hutchinson, A. J.	126, Hockley Hill.
Huxley, T. H., LL.D., F.R.S. (*Hon. V.P.*)	4, Marlborough Place, St. John's Wood, N.W.
Huxley, Dr. J. C..	91, Harborne Road.
Iles, Fred...	Greenhill Road, Moseley.
Iliff, G. M...	19, Bull Street.
Impey, R. L.	Waterloo Street.
Innes, J.	Moseley.
†Jermyn, Miss E.	12, Islington Row.
Johnson, Alfred	7, George Street, Parade.

Johnson, Miss	Packwood Grange, Knowle.
Johnstone, George Hope ..	Headingley, Hamstead, Handsworth.
Johnstone, William F.	24, Westminster Road.
Jones, George, M.R.C.S. ..	Newhall Street—11, Hagley Road.
Jones, T. Walter	Villa Road, Handsworth.
Jones, W. H.	Livingstone Road, Handsworth.
Jones, W.	Stephenson Chambers, New Street.
Keep, J. S...	Park Road, Edgbaston.
Kenrick, G. H.	Maple Bank, Church Road, Edgbaston.
Kent, W. Saville, F.L.S., F.R.M.S. (*C*)..	Aston House, St. Stephen's Avenue, Shepherd's Bush, London, W.
Ketley, Charles	7, Belle Vue Terrace, Smethwick.
Ketley, Charles B. . ..	7, Belle Vue Terrace, Smethwick.
Lambert, Streeter	Sunnyside, Ampton Road.
Lancaster, W. J., F.C.S.. ..	3, Snowdon Villa, Heathfield Road, Handsworth.
Lapworth, Professor C., F.G.S.	The Mason College.
Latham, W. B.	Botanical Gardens.
Leigh, James	King's Norton.
†Levick, John (*P*)	89, Lime Tree Villas, Albert Road.
Lewis, John, F.S.S.	Victoria Road, Harborne.
Lingard, Geo.	Hildathorpe, Park Hill, Moseley.
†Linn, D. J.	124, Soho Hill, Handsworth.
Littlewood, W.	West Bromwich.
Lloyd, R. M.	19, Spring Hill.
Lloyd, Jordan, M.B., F.R.C.S.. .	21, Broad Street.
Lloyd, J., M.B.	Coventry Road.
Lloyd, J. H., B.A.	Edgbaston Grove, Church Road.
Lloyd, Wilson	Wednesbury.
†Lovett, W. J.	102, Carver Street.
Luckett, J.	Great Colmore Street.
Madeley, F.	Ox Hill, Handsworth.
Madison, J.	62, Camp Hill.
Mantell, C., jun.	21, Cregoe Street.
Mapplebeck, John E., F.L.S. ..	Hartfield, Moseley Wake Green.
Marrian, J. R.	Adzor House, Lozells Road.
Marrian, Mrs. J. R.	Adzor House, Lozells Road.
Marris, George	Corporation Street.

Marshall, Professor A. M., M.D. D.Sc., M.A.	15, Augustus Road.
†Marshall, W. P. (*P*)	15, Augustus Road.
Marshall, Mrs. W. P.	15, Augustus Road.
†Martineau, Edgar	Solihull.
Mathews, James	Hungary Hill, Stourbridge.
Mathews, Wm., M.A., F.G.S. ..	Harborne Road, Edgbaston.
Maw, George (*C*)	Benthall Hall, Broseley.
Mayo, Miss Beatrice	Elmshurst, Handsworth Wood.
Mayo, R.	Elmshurst, Handsworth Wood.
Miles, George	Vyse Street.
†Miller, Herbert	12, Islington Row.
Mitchell, A. B.	213, Hagley Road, Edgbaston.
Mitchell, F. W. V. (*L*)	212, Hagley Road, Edgbaston.
Morgan, F. J.	Board School, Moseley Road.
†Morley, J.	Sherborne Road, Balsall Heath.
Morton, E...	Wilson Road, Birchfield.
Myers, Rev. E., F.G.S. (*C*) ..	Claremont Hill, Shrewsbury.
Naden, Thomas	14, Temple Street.
Nash, F. W.	Worcester City and County Bank, Colmore Row.
Nelson, William (*L*)	Freehold Street, York Road, Leeds.
Nevill, R. A.	Richmond Road, Handsworth.
Newton, R. A.	Newhall Street.
Norris, Hill, M.D.	Walsall Road, Birchfield.
Norris, R., M.D.	Walsall Road, Birchfield.
North, C.	Selly Oak.
Oliver, J. W.	271, St. Vincent Street.
Osler, Miss A.	South Bank, Harborne Road.
Owen, Lloyd	Newhall Street.
Painter, Rev. W. H. (*C*).. ..	Park Hill, Knowle Road, Bristol.
Panton, G. A., F.R.S.E. ..	95, Colmore Row.
Parkes, W. E., M.D.	Soho Hill, Handsworth.
†Parsons, C. T.	Norfolk Road, Edgbaston.
Parsons, Mrs. C. T.	Norfolk Road, Edgbaston.
Parsons, Miss Mary	Norfolk Road, Edgbaston.
Parsons, Miss J. C.	Norfolk Road, Edgbaston.
†Parsons. J...	Hall Street.
Payton, Councillor H.	Eversley, Somerset Road.
Pearson, W. H.	Colmore Row.

Pemberton, G. Arthur	21, Beaufort Road, Edgbaston.
Pendleton, W.	19, Northampton Street.
Percival, Exley (*C*)	Grassendale, Carlyle Road, Edgbaston.
Perrins, G. R.	South View, Cape Hill.
Phillips, J. T.	204, Broad Street.
Phillips, Wm., F.L.S. (*C*)	Canonbury, Kingsland, Shrewsbury.
Phipson, A.	Metchley Lane, Harborne.
Pickering, E. T.	17, Noel Road.
Pickering, J. W.	161, Belgrave Street.
†Player, J. H., F.C.S.	31, Calthorpe Road.
Player, J., F.R.G.S.	Chad House, Edgbaston.
Player, W. D.	19, Chad Road, Edgbaston.
†Pointon, A.	Temple Row.
Pope, J.	King's Norton.
Potts, J.	Bennett's Hill.
President of the Royal Microscopical Society (*C*)	King's College, London.
†Pumphrey, C. (*L*)	King's Norton.
Pumphrey, J. H.	Regent Works, Herbert Road, Small Heath.
†Rabone, J.	Penderell House, Hamstead Road.
Rabone, Mrs. J.	Penderell House, Hamstead Road.
Randall, Rev. Wm., M.A.	Handsworth Rectory.
Reynolds, E. J.	Beaufort Road, Edgbaston.
Richardson, W. E.	59, Varna Road.
Roberts, T. V.	The Crescent, Murdock Road, Handsworth.
Robinson, A. E.	Milton Villa, Beech Lanes.
Robinson, C. R.	25, Legge Lane, Graham Street.
Robinson, E., M.D.	Bristol Road.
Robison, R.	Royal Insurance Company, Bennett's Hill.
†Roderick, John	Hanbury Place, Rose Hill, Handsworth.
Rooke, W.	Augusta Road, Moseley.
Rowlands, Joseph	71, Colmore Row.
Ryland, W. P.	Redlands, Erdington.
†Saunders, C. H.	Robert Road, Handsworth.
Sayer, H. J.	Cambridge Street.
Schwarz, Dr. G. C. T.	Queen's College.
Sharp, Councillor	397, Bristol Road.
Sharpus, F. W. (*C*)	30, Compton Road, Highbury, London.
†Sherwood, William	The Garth, Wylde Green.
Shoebotham, J. H.	Highfield, Hermitage Road, Edgbaston.

Short, R. M.	Solihull.
Simcox, A...	12, Calthorpe Road.
Simmonds, W. H.	99, Ravenhurst Street.
Simpson, E. (*C*)	24, Grammont Road, Peckham Road, London, S.E.
Simpson, T.	6, Waterloo Street.
Slocombe, J.	Grosvenor House, Hall Road, Handsworth.
Smedley, W. T., F.R.A.S. ..	57, Colmore Row.
Smith, Edwin	19, Elvetham Road.
Smith, G.	326, Bristol Road.
Smithson, J.	Sunbreak, Wellington Road.
Southall, H. W.	Coppice Road, Moseley.
†Southall, William, F.L.S. (*P*) ..	Sir Harry's Road, Edgbaston.
Sowton, A...	Fir Tree Cottage, High Street, Harborne.
Spencer, Herbert (*Hon. V.P.*) ..	38, Queen's Gardens, Kensington.
Spencer, J...	Sandwell Villas, Birmingham Road, West Bromwich.
Spinks, W...	Royal Nurseries, Harborne Road.
Srawley, J.	102, Westminster Road, Handsworth.
Srawley, Mrs. J.	102, Westminster Road, Handsworth.
Stevens, Wm.	Handsworth.
Sturge, Joseph	Wheeley's Road.
Sturge, Wilson	Frederick Road, Edgbaston.
Swayne, R. A.	Rostrevor House, Hobmore Lane, Small Heath.
Symonds, Rev. W. S. (*C*) ..	Pendock Rectory, near Tewkesbury.
Tait, G. W., M.R.C.S.	Knowle.
Tangye, G...	Heathfield Hall, Handsworth.
Taunton, Miss F. M.	10, Yew Tree Road, Edgbaston.
Taunton, J. R. C...	116, Bristol Road.
Taylor, Reuben	Colmore Row.
Thomas, Dr. Wynne	8, Harborne Road.
Thomason, George	88, Hagley Road.
†Timmins, Sam., J.P.	Elvetham Road, Edgbaston.
Timmins, Mrs. Sam.	Elvetham Road, Edgbaston.
Timmis, J. M.	18, Rose Hill, Handsworth.
†Touks, Edmund, B.C.L. (*P*) ..	Packwood Grange, Knowle.
Toon, James	Pershore Road.
Turnbull, J. R.	Colmore Row.
Turner, A...	6, Claremont Road, Handsworth.
Turner, John	6, Stirling Road.

Twamley, C. .. .. .. Ryton-on-Dunsmore, Coventry.
Twigg, G. H. .. .. .. 21, Summer Hill.
Tye, G. S. .. .. 62, Villa Road, Handsworth.
Tyerman, J. (C) .. .. .. Penley, Tregony, Cornwall.

Udall, J. .. .. 77, Summer Hill.
Underhill, F., M.R.C.S... .. 263, Moseley Road.

Vicars, J. .. .. 47, Hartington Road, Liverpool.
Vize, Rev. J. E., M.A. (C) .. Forden Vicarage, near Welshpool.

Wade, W. F., M.D. .. .. Temple Row.
Wagstaff, E. H. .. .. .. 1, Waterworks Road, Edgbaston.
Waller, T. H., B.A., B.Sc., Lond. 71, Gough Road.
Walliker, S. .. .. .. Post Office, Birmingham.
Walton, F. A. .. .. .. Hamstead Road.
Warden, Chas., M.D. .. .. 31, Newhall Street.
Watson, C. J. .. .. .. 34, Smallbrook Street.
Webb, A. J. .. .. .. St. Paul's Road, Moseley.
Welch, Dr. J. B. .. .. .. Medical Officer of Health for Handsworth.
Wells, S. J. .. .. .. 15, Bath Street, Southport.
White, Councillor W. .. .. Sir Harry's Road, Edgbaston.
Whitefoot, T., jun. .. .. 36, High Street, Bridgnorth.
Whitehouse, W. .. .. .. Myrtle Villa, Broomfield, Smethwick.
Wilkes, J. B. .. .. .. The Holy Well, Claverdon, Warwick.
Wilkins, Silvanus .. .. The Haye, Lyme Regis, Dorset.
Wilkinson, A. W... .. .. Pershore Road.
Wilkinson, Captain .. .. Elmwood, Hamstead, Handsworth.
Wilkinson, Mrs., sen. .. .. Ariston, Hamstead Road, Handsworth.
Wilkinson, Walter .. .. Shobnall House, Handsworth Wood.
†Wilkinson, W. H... .. .. Great Hampton Street.
Williams, S. D., jun. .. .. Easy Row.
Willis, John .. .. .. 1, Calthorpe Road, Edgbaston.
Willis, W. (C) .. .. .. 49, Palace Grove, Bromley, Kent.
Willmore, F. W. .. .. .. The Willows, Walsall.
†Wills, A. W. (P) .. .. .. Claregate, Wylde Green, Erdington.
Wills, Mrs. A. W. .. .. Claregate, Wylde Green, Erdington.
Wills, Miss L. E... .. .. Claregate, Wylde Green, Erdington.
†Wilson, G. E. .. .. .. West Hill, Augustus Road.
Wilson, Wright, F.R.C.S. Edin., F.L.S... .. .. .. 21, Crescent.
Withers, F. .. .. .. Rope Walk, Farm Street.
Woodman, W. .. .. .. Trafalgar Road, Moseley.

Woodward, C. J., B.Sc., F.G.S.	97, Harborne Road.
Wright, J. H.	Malvern Villas, Soho Hill.
Wright, Mrs. J. H.	Malvern Villas, Soho Hill.
Wright, Richard (*C*)	Holly Bank, Sale, near Manchester.
Wright, T., M.D., F.R.S. (*C*) ..	Cheltenham.
†Wynn, J. C.	Court Oak Road, Harborne.
†Yeoman, W. C.	Park Villa, Solihull.
†Young, H. S.	240, Upper Street, Islington, London.

ASSOCIATES.

AGE.		
18	Allport, Frank	Colmore Row.
17	Blatch, W. G., jun.	Albert Villa, Green Lane.
17	Dammann, J. F. R... ..	22, Francis Road.
17	Harrison, W. J., jun. ..	365, Lodge Road.
18	Johnstone, F. W.	24, Westminster Road.
16	Matley, C. A..	49, Godwin Street, Ashted.
17	Saunders, J. V.	137, Birchfield Road.
17	Stone, H.	Cavendish House, Grosvenor Road, Handsworth.
17	Tregilgas, F. J.	3, Windsor Place, Churchill Road, Handsworth.
18	Wynne, A. E.	King Edward's School.

MEMBERS ELECTED SINCE JANUARY 1st, 1883.

Ballard, J. F.	Jester Villas, Cape Hill, Birmingham.
Butler, Walter	36, Broad Street.
Carter, E. M.	Hazelwood, Edgbaston.
Castley, Miss M. de	2, Upper Priory.
Cullis, F. J.	28, Claremont Road, Handsworth.
Cund, Thomas	Paternoster Row, Birmingham.
Dewes, Henry	19, Duchess Road, Edgbaston.
Felton, C. F.	Noel Road, Edgbaston.
France, F. H.	Sandford Road, Moseley.
Goode, Mrs..	The Moors, Church Lane, Handsworth.
Green, Wm. J.	Ivy Cottage, Booth Street, Handsworth.
Hayes, A., B.A.	Prospect Road, Moseley.
Hudson, R. W.	Bache Hall, Chester.

Major, L. J.	The Bhylls, near Wolverhampton.
Mason, James	Bratt Street, West Bromwich.
Organ, Jas.	88, King Edward's Row.
Peacock, E.	11, Devonshire Place, Portland Place, London, W.
Pearson, H. A.	Far Croft, Handsworth.
Plowright, C. B., M.R.C.S. (C) ..	7, King Street, King's Lynn.
Sonnenschein, Professor ..	The Mason College.
Treadwell, John	123, Gough Road, Edgbaston.
Wilkins, Mrs. S.	The Haye, Lyme Regis, Dorset.

Birmingham Natural History and Microscopical Society.

LIST OF OFFICERS FROM 1864 TO 1882 INCLUSIVE.

*** *THE BIRMINGHAM NATURAL HISTORY ASSOCIATION was founded in* 1858, *and was reconstructed in the year* 1864 *under the present title.*

	PRESIDENT.	VICE-PRESIDENTS.	TREASURER	SECRETARY.	LIBRARIAN.	CURATORS.
1864	W. R. Hughes, F.L.S.	William Willis Thomas Fiddian	George Heaton	Charles Adcock	A. E. Fardon	C. J. Woodward.
1865	W. R. Hughes, F.L.S.	Thomas Fiddian L. Percival	George Heaton	James Hinds, M.B.	Thomas Scott	E. J. Chitty.
1866	W. R. Hughes, F.L.S.	Thomas Fiddian L. Percival	George Heaton	Thomas Jephcott	Thomas Scott	E. J. Chitty.
1867	Jas. Hinds, M.B.	C. T. Parsons W. P. Marshall, C.E.	George Heaton	Thomas Jephcott	Thomas Scott	Fras. Fowke.
1868	Samuel Allport, F.G.S.	W. P. Marshall, C.E. W. Mathews, jun., M.A.	George Heaton	A. W. Wills	George Crofts	Fras. Fowke.
1869	W. P. Marshall, C.E.	William Hinds, M.D. Edward Myers, F.G.S.	George Heaton	A. W. Wills	George Crofts	James E. Bagnall.
1870	William Hinds, M.D.	Edward Myers, F.G.S. A. W. Wills	Charles Pumphrey	Edward Simpson	James E. Bagnall	W. B. Latham. John Morley.
1871	A. W. Wills	J. W. Cotton, F.G.S. Rev. H. W. Crosskey, F.G.S.	Charles Pumphrey	W. G. Blatch	John Morley	James E. Bagnall. G. Sherriff Tye.
1872	Rev. H. W. Crosskey, F.G.S.	Jas. E. Bagnall Rev. G. Deane, D.Sc	Charles Pumphrey	W. G. Blatch	John Morley	R. M. Lloyd. G. Sherriff Tye.
1873	W. R. Hughes, F.L.S.	Rev. H. W. Crosskey, F.G.S. Rev. G. Deane, D.Sc.	Charles Pumphrey	W. G. Blatch	John Morley	R. M. Lloyd. W. Nelson.
1874	Rev. G. Deane, D.Sc., F.G.S.	Edmund Tonks, B.C.L. John Morley	Charles Pumphrey	W. Wright Wilson, F.L.S.	James E. Bagnall.	J. W. Cotton, F.G.S. Thomas Fiddian.
1875	A. W. Wills	John Morley Lawson Tait	Charles Pumphrey	W. Wright Wilson, F.L.S.	James E. Bagnall.	J. W. Cotton, F.G.S. G. Sherriff Tye.
1876	Lawson Tait, F.R.C.S.	Walter Graham Edmund Tonks, B.C.L.	Charles Pumphrey	C. B. Caswell John Morley	James E. Bagnall	G. Sherriff Tye. G. Edmonds.
1877	Edmund Tonks, B.C.L.	Walter Graham G. Sherriff Tye	Charles Pumphrey	John Morley	James E. Bagnall	John Levick. W. H. Cox.
1878	Edmund Tonks, B.C.L.	Walter Graham E. W. Badger	Charles Pumphrey	John Morley	James E. Bagnall.	John Levick W. H. Cox.
1879	W. Graham, F.R.M.S.	E. W. Badger W. Southall, F.L.S.	Charles Pumphrey	John Morley H. E. Forrest	James E. Bagnall	John Levick W. H. Cox.
1880	W. Southall, F.L.S., F.R.M.S.	E. W. Badger John Levick	Charles Pumphrey	John Morley H. E. Forrest, F.R.M.S.	James E. Bagnall	W. B. Grove, B.A. R. M. Lloyd.
1881	Edward W. Badger	John Levick T. H. Waller	Charles Pumphrey	John Morley W. B. Grove, B.A.	James E. Bagnall.	R. M. Lloyd. E. W. Jones, F.C.S.
1882	John Levick, F.R.M.S.	T. H. Waller, B.A., B.Sc. W. G. Blatch	Charles Pumphrey	John Morley W. B. Grove B.A.	James E. Bagnall.	R. M. Lloyd. H. Miller.

The Treasurer in Account with the Birmingham Natural History and Microscopical Society.

GENERAL ACCOUNT.

Dr.

1882.	£ s. d.	£ s. d.
To Subscriptions		
Arrears ...	23 11 0	
For 1882 ...	122 18 0	
For 1883 ...	19 11 0	
		166 0 0
,, Balance from Apparatus Fund		21 14 0
,, Balance from Soiree of 1881		0 1 10
,, Balance due to Treasurer ...		28 0 0
		£215 15 10

Examined and found correct,

JOHN EDMONDS,
J. W. PICKERING, } Auditors.

Cr.

1882.	£ s. d.	£ s. d.
By Balance brought forward ...		11 15 11
,, Books and Binding ...		35 1 1
,, Printing, viz.:—		
Annual Reports ...	24 16 4	
Illustrations for Reports 1882 and 1883 ...	9 3 3	
Programmes, &c. ...	8 10 0	
Illustrations for the "Naturalist" ...	13 11 8	
		56 4 3
,, Postage, viz.:—		
Per Secretaries ...	13 10 2	
,, Treasurer ...	2 10 6	
For Soirees ...	2 0 0	
,, Excursions ...	1 1 4	
		19 2 0
,, 268 Copies of the "Naturalist" in 1878 ...		1 9 3
,, Loss by Excursions ...		2 11 5
,, Curator's Salary and Commission ...		36 13 0
,, Rent and Insurance, etc. ...		17 14 0
,, Subscription to Midland Union ...		3 18 0
,, ,, to Darwin Prize ...		3 3 0
,, Carriage and Sundries ...		1 8 3
,, Stationery ...		0 5 6
,, Balance of Furnishing Fund ...		23 10 2
		£215 15 10

The Treasurer in Account with the Furnishing Fund.

Dr.	£	s.	d.	Cr.	£	s.	d.
1882.				1882.			
To Balance in Hand ...	1	0	7	By Paid J. Morley—Interest ...	3	15	0
,, Special Donations ...	55	0	0	,, ,, ,, Principal ...	75	0	0
,, Balance from General Account ...	23	10	2	,, Sundry Purchases ...	0	15	9
	£79	10	9		£79	10	9

Apparatus Fund.

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NOTE.—Since 1861 £1,047 has been expended in Books, Apparatus, and Furniture by the Society. Numerous valuable presents of Books and Apparatus have also been received. Subscriptions due far exceed all outstanding liabilities.

CHARLES PUMPHREY, Hon. Treasurer.

REPORT ON THE PENNATULIDA COLLECTED IN THE OBAN DREDGING EXCURSION OF THE BIRMINGHAM NATURAL HISTORY AND MICROSCOPICAL SOCIETY, JULY, 1881.

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[*Read before the Society, December 20, 1881.*]

The specimens of Pennatulida or Sea-pens obtained in the Oban dredging excursion, and placed in our hands for description, include examples of three species, *Pennatula phosphorea*, *Virgularia mirabilis*, and *Funiculina quadrangularis*, belonging to three distinct genera and even families. The following table, abridged from the scheme of classification proposed by Kölliker in his Report on the Pennatulida collected by H. M. S. Challenger,* shows the relative positions and affinities of the three genera:—

ORDER.—PENNATULIDA.

SECTION I.—*Pennatuleæ:* polypes on leaves.
- Family 1. *Pteroeididæ.*
- Family 2. *Pennatulidæ.*
  - Genus, *Pennatula.*
- Family 3. *Virgularidæ.*
  - Genus, *Virgularia.*
- Family 4. *Stylatulidæ.*

SECTION II.—*Spicatæ:* polypes sessile.
- Family 1. *Funiculinidæ.*
  - Genus, *Funiculina.*

SECTION III.—*Renilleæ:* rachis expanded in form of a leaf.

SECTION IV.—*Veretilleæ:* polypes arranged radially, not bilaterally.

Of the three genera with which we are concerned *Funiculina* is the rarest, and in many ways the most interesting, and we therefore propose to deal with it first, reserving *Pennatula* and *Virgularia* for subsequent consideration. An additional reason for adopting this course is afforded by the fact that while the internal structure of *Pennatula* and *Virgularia* has been described and figured by various writers, that of *Funiculina* is known to us only through the very careful and elaborate description given by Kölliker in his monograph on the Pennatulida;† and this description, though very full, is yet incomplete in some points on which the opportunity of examining perfect specimens, either living or recently preserved, has enabled us to throw some light.

We have devoted special attention to the figures illustrating this report, all of which have either been drawn direct from the object with the aid of a camera, or else, where—as in Plate I. Fig. 3—it was

* Kölliker: "Zoology of Challenger Expedition," Part II., 1880, pp. 33–35.

† Kölliker: "Anatomisch-systematische Beschreibung der Alcyonarien; Erste Abtheilung: Die Pennatuliden," 1872, pp. 250–261.

impossible to obtain a direct view in the required position, have been compiled from several camera drawings of the individual parts concerned. We desire to lay some stress on this point, inasmuch as the figures of *Funiculina* hitherto published* are either very inaccurate, or if correct, as is the case with Kölliker's figures, are taken from specimens with the tentacles completely retracted, and consequently fail to express accurately the appearance of the living animal.

PART I.

FUNICULINA QUADRANGULARIS. PALLAS.

Of this rare and interesting species the following specimens were obtained:—

a. Four living specimens: one a remarkably large and perfect example, thirty-nine inches in length: a second, smaller and less mature specimen, twenty inches in length: and two much smaller ones of ten and eight inches length respectively.

b. Three complete skeletons or calcareous stems, of twenty-four, twenty, and sixteen inches length respectively; and sixteen fragments of stems, varying in length from four to twenty inches. Some of these are still encrusted with portions of the cœnenchym, or fleshy body-substance, and must, therefore, have belonged to specimens only recently dead: the majority, however, are quite clean and white, and appear, therefore, to have been dead for some time.

The specimens of *Funiculina* were dredged at two spots about a mile apart; one of these about three miles N.W. of Oban, and midway between the mainland and Lismore Point, the southern extremity of Lismore Island; the other about half-a-mile S.E. of Lismore Point.† The depth of water in both cases was about twenty-two fathoms, and the bottom mud.

The living specimens were kept in sea water for one to three days, and then transferred to spirit. In order to study the anatomy of the polypes a few have been removed from different portions of the colony; and of these sections, either transverse or longitudinal, were made, which, when cleared with a mixture of creosote and turpentine and mounted in balsam, made very satisfactory preparations. The specimens proved to be in better histological condition than was anticipated from the method of preservation, but cannot be relied on to determine doubtful points of microscopic structure. It is highly desirable that in future expeditions more attention should be paid to this very important point.

The following description, which has been drawn up from the

* A full list of all the figures of *Funiculina* hitherto published is given at the end of this paper in connection with the literature of our subject.

† *Vide* "General Report on the Dredging Expedition," by J. F. Goode and W. P. Marshall, in which the first locality is marked Station III., the second, Station VI.

preparations obtained in the above manner, applies, except when otherwise specified, to the largest of the specimens obtained alive.

GENERAL ACCOUNT.

Funiculina is a compound or colonial Actinozoon, whose general appearance is shown in Plate I., Fig. 1. It consists of a cylindrical, fleshy axial portion, the lower ⅓th of which is bare, forming the *stalk* (Fig. 1, *b*), which in the natural condition is planted in the mud of the sea bottom, while the upper ⅔ths, forming the *rachis* (Fig. 1, *a*) is thickly studded with the individual animals or *polypes*, each of which is similar in structure to an ordinary sea-anemone.

The axial portion, which is gracefully curved as shown in the figure, is traversed throughout its whole length by a solid calcareous *stem*, quadrangular in section, and shown in Fig. 2 free from the investing fleshy substance or *cœnenchym*.

At the bottom of the rachis the polypes are few and small; but passing upwards they gradually increase in both number and size, attaining a maximum in the upper third. They are not placed all round the rachis, but on three sides only, leaving the fourth bare. This, which is the inner or concave side of the curve formed by the whole rachis, is referred to as the *ventral surface* (Figs. 3 and 5): the opposite or convex face (Figs. 1, 3, and 4) is the *dorsal surface*, while the sides are referred to as *right* and *left lateral surfaces* respectively.

The whole pen is of an ivory-white colour* except the stalk, which is yellowish brown. The surface is covered with a slimy mucus, and is in the living animal, according to both Forbes and Thomson,† brilliantly phosphorescent.

The term *feather*, which is often used to designate the rachis and polypes together, calls to mind the fanciful name *Penna del pesce pavone* (feather of the peacock fish) given to *Funiculina* by the Neapolitan fishermen, under which name it was described in 1757 by Bohadsch, the discoverer of this very curious Sea-pen.

ANATOMICAL DESCRIPTION.

1.—*The Stalk and Rachis.*—

The stalk in the large specimen measures six inches in length. Along its greater part it is cylindrical, with a diameter of 0·15 inch; toward the lower end it enlarges to 0·21 inch. The last ¾-in. is bent rather sharply, nearly at right angles to the main axis (Fig. 1), and ends in a blunt point. The upper part of the stalk diminishes gradually in size, loses its cylindrical form and becomes quadrangular, the lateral diameter slightly exceeding the dorso-ventral one. At the junction of stalk and rachis the actual measurements are—lateral diameter, 0·13in.; dorso-ventral diameter, 0·10in.

The rachis gradually increases in thickness in passing upwards from its junction with the stalk; it also loses its quadrangular form

* Both Forbes ("Johnston's British Zoophytes," 2nd ed., 1847, p 165) Thomson ("Depths of the Sea," 1873, p, 149) describe the living *Funiculina* a rose-coloured.

† Forbes, *loc. cit.* Thomson, *op. cit.*

and becomes cylindrical. At about six inches from the top (Fig. 3), at which point it attains its greatest size, the diameters are—lateral, 0·22in.; dorso-ventral, 0·20in.; above this point it tapers rapidly to the top.

We have been unable to examine the internal structure of the stalk and rachis, as the specimens were destined for museum purposes. Kölliker* has shown, however, that they are traversed along their whole length by four main longitudinal canals (Fig. 3, *u*), one dorsal, one ventral, and two lateral, from which smaller canals arise forming a rich network of nutrient vessels traversing the cœnenchym, and communicating, as we shall see shortly, with the body-cavities of the polypes. We have been able to confirm the existence of these main canals, though we have not had an opportunity of tracing them along their whole length. The smaller canals, with their openings into the cavities of the polypes are shown in Plate II., Figs. 10 and 15, *v*.

The integument of both stalk and rachis is, according to Kölliker, thick, and closely studded with minute fusiform calcareous spicules.†

In stating that the stalk is, in the natural condition, inserted in the mud of the sea bottom, we rely mainly on the very definite statement of Forbes, who says:‡ "It lives erect, its lower extremity, as it were, rooted in slimy mud." Additional evidence on the point is yielded by the anatomical arrangement of the parts, especially of the stem (as will be noticed immediately); and by the fact that the allied genus *Virgularia* is known to live erect.§ Sir Wyville Thomson also speaks of "passing over a forest" of *Funiculina*, clearly implying that they live erect.

2.—*The Stem.*—

The stem (Fig. 2) extends from the top of the rachis to within a short distance of the lower end of the stalk. As shown in Fig. 3 *c*, it is quadrangular in section, but the sides are not perfectly flat. The dorsal surface is slightly convex (flat in some specimens) along the greater part of its length, but becomes concave in the stalk: the ventral surface is slightly concave; while the lateral surfaces, which are rather narrower than the dorsal and ventral ones, are decidedly concave.

The stem is thickest at the junction of the rachis and stalk, where its transverse diameter is 0·10 in., its dorso-ventral diameter 0·08 in. From this point it tapers towards the upper end, at first very gradually, then more rapidly; its upper part being very slender and flexible: towards the lower end it tapers gradually for a short distance, and then rapidly, ending in a fine flexible and imperfectly calcified point which enters the bent portion of the stalk, and ends a very short distance from its extremity.

* *Op. cit.*, pp. 253-254. † *Op. cit.*, p. 253, and Plate XVIII., Fig. 151.
‡ "Johnston's British Zoophytes," 2nd edition, 1847, Vol. i., p. 165. Cf. also Richiardi, "Monografia della Famiglia dei Pennatularii," p. 91.
§ Darwin, "Naturalist's Voyage Round the World," 1860, p. 99.
‖ Thomson, "Depths of the Sea," 1873, p. 149.

It is thus seen that the thickest part of the stem is at the point where the fleshy cœnenchym is thinnest; indeed, as is seen from the measurements given above, the total thickness at this point—the junction of rachis and stalk—is due almost entirely to the stem, which is here covered by a layer of cœnenchym so thin that the quadrangular shape of the stem is evident on mere inspection.

A point of much greater interest, and one on which we think some stress should be laid, is that the proportions of the stem at various points of its length are such as, mechanically considered, to adapt it most perfectly to what we regard, for the reasons stated above, as its normal position, *i.e.*, planted erect with the stalk buried in mud and the rachis projecting freely above it into the water. In this position the thickest and strongest portion of the stem is at the point where most strength is needed, *i.e.*, at the surface of the mud. The gradual tapering downwards in the first part of the stalk gives a firm, rigid support, while the gradual and steady tapering towards the upper end of the rachis provides the requisite strength in the lower part with increasing flexibility in the upper. So marked, indeed, is this adaptation of the shape of the stem to the form of the whole Pen that it would alone be an argument of no inconsiderable weight in favour of the erect position being the natural one.

The lower part of the stem is very stiff, rigid, and brittle; the upper part is highly flexible, so that the two ends of the stem may be brought together without the slightest danger of breaking.

The stem itself, when freed from the cœnenchym, preserves the very graceful curve already referred to, and well shown in Fig. 2, which is drawn from the largest of the three perfect specimens of stems dredged up.

Of the sixteen fragments of stems obtained, one 12 ins. in length and with scarcely any curvature, must, from its size, have belonged to a specimen at least as large as, and probably larger than, the big living specimen. The other fragments belonged, so far as we can judge, to specimens averaging from 18 ins. to 36 ins. in length. In the curvature and relative proportions of its parts the stem of *Funiculina* offers a marked contrast to that of *Virgularia*, which we shall describe in a subsequent section of this report. The differences are important, as they appear to be directly connected with certain very marked differences in the habits of the two genera.

Transverse sections through the stem show that it consists of a central core which is chitinous and only very imperfectly calcified, and an outer very hard, and firmly calcified rind, with a smooth outer surface, and made up of parallel lamellæ. As the stem grows in thickness by the addition of successive lamellæ on its exterior, and as the proportions between the hard outer rind and the soft core are much the same in both young and old specimens, it is clear that the process of deposition of calcareous lamellæ on the outside must be accompanied by absorption of the calcareous matter previously deposited in the more central portion.

3.—*The Polypes and Zooids.*—

As among Pennatulida generally* the individual animals composing the colony are of two kinds, distinguished as *polypes* and *zooids*: the polypes (Figs. 3 and 4, *d*) being distinguished by their greater size, and by possessing tentacles and reproductive organs, while the zooids, (Figs. 3 and 4 *e*), are smaller, and have neither tentacles nor reproductive organs.

In *Funiculina*, the zooids form an irregular row on the mid-dorsal surface (Figs. 3 and 4), on either side of which the polypes are placed; but the distinction between polypes and zooids is far less marked than in the majority of Pennatulida, and it is very doubtful whether any sharp line can be drawn between the two forms. In young specimens especially the transition is a perfectly gradual one, and a complete series of intermediate forms can be obtained between the largest polypes and the smallest zooids.

Confining the term zooid to the small individuals destitute of tentacles, the arrangement of the polypes and zooids on the rachis is as follows:—At the lower end of the rachis there are no polypes at all, and merely a single longitudinal row of small zooids, situated along the ventro-lateral angle of the quadrangular rachis. Passing upwards, the zooids increase in both size and number, and pass obliquely across the side of the rachis to the dorso-lateral angle, which they reach about 2 ins. above its commencement. Above this point they gradually shift on to the dorsal surface, where they form an interrupted and irregular longitudinal median row from three to five zooids wide, extending to the extreme top of the rachis.

The first polypes are found about 2 ins. above the commencement of the rachis, and on the middle of the lateral surfaces. They lie on the ventral side of the zooid rows, and are at first in a single row on either side, and at rather wide intervals apart. About an inch higher up the rows become double, and beyond this point the polypes increase rapidly in number and size. For a short distance they are clearly arranged in oblique rows, ascending from the ventral side below to the dorsal side above; but along the greater part of the rachis they are clustered so closely together that it is difficult to make out any definite arrangement in rows, though a closer examination shows, as Kölliker has already pointed out,† that they are really arranged in ill-defined, somewhat triangular groups, the apices of the triangles being situated on the ventro-lateral angles of the rachis and about ¼ in. apart, while the bases are on the dorsal surface in contact with the median zooid tract.

The polypes cover the whole of the lateral surfaces of the rachis and the marginal portion of the dorsal surface, but do not extend on to the ventral face (Figs. 3, 4, 5). Throughout the whole length of the rachis the polypes on the dorsal surface are the smallest, those on the lateral surfaces gradually increase in size, and those along the

* Kolliker, *op. cit.*, p. 6. † *Op. cit.*, p. 257.

ventro-lateral angles are the largest of all (Fig. 3). These latter may, as shown in Fig. 5, encroach somewhat on the ventral surface.

The polypes are largest and most closely placed in the uppermost 12 ins. of the rachis, where they form a thick heavy mass, completely weighing down the top when taken out of water. The greatest width of the feather, at 6 ins. from the top, is ¾ in.

The ventral surface has an average width of 0·14 in. It is not perfectly straight throughout, but becomes curiously twisted at one or more points, the most marked of which is 10½ ins. from the upper end, and is indicated in Fig. 1. These twists are apparently due to some irregularity in growth, though it is quite possible that the fleshy cœnenchym, as shown by Sir J. Dalyell to occur in *Virgularia*,* may be able during life to twist itself round the calcareous stem, and so cause the distortion in question.

The largest polypes measure 0·30 in. in length, by 0·08 in. in width; the larger zooids are 0·05 in. long, and the smallest ones are minute warts. As already mentioned, it is impossible, in many cases, to distinguish between the larger zooids and the smaller polypes, and we are strongly disposed to view the former as being, at any rate in many cases, only polypes that have not yet reached maturity. At the most crowded part there are about fourteen rows of polypes per inch length of the rachis, with nine polypes in each row. The total number of polypes may be estimated at about 3,000.†

The smaller specimens obtained living differ from the larger one above described in the following points (Fig. 6):—The general proportions are very similar, but the actual size of the largest polypes is less than those of the large specimen: the polypes are also far less closely packed, considerable portions of the dorsal and lateral surfaces being left bare between the bases of the polypes and zooids: the polypes instead of being closely massed together in dense clusters are distinctly arranged in oblique rows along the whole length of the rachis. Furthermore the gradual transition from zooids to polypes is far more evident than in the larger specimen.

These differences between the larger and smaller specimens of *Funiculina* are of some zoological interest. Verrill,‡ from a comparison of several Scotch specimens with ones from the Mediterranean, concluded that they belonged to distinct species, and proposed the name *Funiculina Forbesii* for the Scotch one. Concerning it he says: "It is much more slender than the latter (*F. quadrangularis*, the Mediterranean form) with far less numerous and crowded polypes; these are arranged in oblique series of two or three, instead of five;

* Sir John Graham Dalyell, "Rare and Remarkable Animals of Scotland," 1848, Vol. ii., p. 185.

† The above description of the largest of the Oban specimens will be found to agree very closely with that given by Kolliker (*op. cit.*, pp. 257–258) of a very fine specimen 53 ins. in length, obtained from the Danish coast, and now in the Museum of Copenhagen.

‡ A. E. Verrill: List of the Polypes and Corals sent by the Museum of Comparative Zoology to other Institutions in exchange, with annotations. Bulletin of the Museum of Comparative Zoology of Harvard College, 1864, p. 30.

the outer ones are the largest, those occupying the central region being rudimentary and papilliform, but all are disproportionately smaller than those of *F. quadrangularis*." Dr. Gray* adopts this division, and assigns the name *F. quadrangularis* to the Scandinavian forms as well as to the Mediterranean ones, distinguishing the Scotch ones, like Verrill, as *F. Forbesii*.

The validity of this distinction has been called in question by Richiardi,† and by Kölliker,‡ both of whom distinctly state that *F. Forbesii* is merely the young form of *F. quadrangularis*, and that they have seen specimens from the Mediterranean forming complete gradational series between the two forms.

The Oban specimens set this question completely at rest, showing that the Scotch forms are not, as Verrill and Gray supposed, all *F. Forbesii*, but that perfectly typical *F. quadrangularis* occur side by side with them. The description given by Verrill applies perfectly to the three smaller living specimens obtained by the Society at Oban, but is contradicted on every point by the large specimen, which is in all respects a perfectly typical specimen of the form *Funiculina quadrangularis*, erroneously supposed by Verrill and Gray to be confined to the Mediterranean and Scandinavian seas. The point is, perhaps, one of no very great importance, but, inasmuch as unnecessary multiplication of species is a very definite evil, the Birmingham Natural History Society may certainly be congratulated on having established the fact that the Scotch *Funiculina* is identical with the Mediterranean and Scandinavian forms, and is not a distinct species.

The large specimen from Oban thus acquires some historical importance, as having been the means of proving this identity. Larger specimens even than that dredged by the Society have indeed been previously obtained from Oban, and there can be little doubt that these fully agreed with the Society's specimen; but of these no complete description has ever appeared, nor are the specimens themselves preserved for reference, so that the Birmingham specimen, which is now permanently deposited in the Zoological Museum of the Mason College, may undoubtedly claim the honour of being *the* typical British example of *Funiculina quadrangularis*.

4.—*Anatomy of the Polypes.*—

The following description of the anatomical and microscopical structure of the polypes is based on the examination of whole specimens and of sections prepared in the manner already noticed.

The structure of a polype is shown in the series of figures on Plate II. Fig. 10 shows a polype bisected longitudinally along its whole length; Figs. 12, 13, 14 and 15 represent transverse sections taken at various points of the length; and Fig. 11 is a more highly magnified section of one of the tentacles.

* J. E. Gray: Catalogue of the Sea-pens or Pennatularidæ in the collection of the British Museum, 1870, pp., 12-13.

† Richiardi: "Monografia della Famiglia dei Pennatularii," Bologna, 1869, p. 66.

‡ Kölliker: *op. cit.*, p. 257.

The polype (Fig. 10) resembles in structure a somewhat elongated Sea-anemone, consisting of a firm body-wall (*k*) continuous below with the fleshy cœnenchym (*l*) of the rachis, and forming above a calyx (*g*), which surrounds the tentacles (*f*) and has its free margin produced into a series of eight pointed processes (Plate I., Fig 7), alternating with the tentacles. The tentacles, eight in number, are hollow (Fig. 10), and are fringed on each side by a series of hollow pinnules.

The tentacles are arranged in a whorl round the mouth (Fig. 10, *m*), which leads into a short tubular stomach (*n*) with folded walls, and opening below into the body-cavity. The stomach is connected with the body-wall by a series of eight vertical mesenteries or septa (Figs. 10 and 13 *o*), which extend below the stomach to the bottom of the body-cavity (Figs. 10, 14, and 15). The free edges of these mesenteries below the stomach are thickened, forming twisted cords—the mesenterial filaments (Figs. 10 and 14, *r*, *s*,); of these two are slender and extend the whole length of the body-cavity (Figs. 10, 14 and 15, *s*), while the other six are thick and short, only extending part of the way down the body-cavity (Figs. 10 and 14 *r*). The free edges of these six mesenteries bear, below the mesenterial filaments, the reproductive organs (Figs. 10 and 15 *t*).

We propose now to describe these several parts in more detail, taking them in the order given above.

a. The Body-wall.—This consists of a firm gelatinous *mesoderm* (Figs. 10, 12, 13, and 14, *x*), which forms the greater part of the thickness of the wall, and is clothed on its outer and inner surfaces by thin cellular membranes—the *ectoderm* (*w*) and *endoderm* (*y*).

The ectoderm, which in our specimens is not in good histological condition, appears to consist of a single layer of columnar cells, which are often much vacuolated and contain, especially in their deeper parts, very numerous, minute, highly-refractive particles of a dark brown colour. So far as we have been able to determine, the ectoderm of the body-wall contains no thread-cells; but on this, and on many other points of interest involving histological determinations, we are unable to speak with certainty, owing to the imperfect preservation of the specimens.

The mesoderm consists of a matrix of considerable thickness and consistence, which in its outer part is homogeneous, but in its inner portion is, in places, more or less distinctly fibrillated. Imbedded in the matrix are cells of two kinds:—(1) Spherical nucleated cells, closely resembling ordinary cartilage-cells in appearance; (2) Fusiform nucleated cells with long processes, which often branch and become connected with the processes of adjoining cells.

The mesoderm is traversed by a network of very fine canals, which are less abundant and of less size in the upper part of the body-wall than at the lower part, where they become continuous with the canal system of the rachis, which has already been described. The finer canals do not appear to have distinct walls, but seem to be mere channels in the matrix of the mesoderm; in the larger canals, however, a very evident epithelial lining is present, which becomes continuous with the endoderm at the points where the canals open into the body-cavity (Figs. 10 and 15). This canal system probably serves to convey nutrient matter from the body-cavity, where it is prepared, to the various parts of the body-walls and cœnenchym; and inasmuch as it communicates with the body-cavities of all the polypes it affords a means by which food digested by one polype may be conveyed to others, and so supply them with nutriment. The canal system forms thus the great bond of union between the several individuals of the colony, connecting them together into one organic whole. To what extent the several members of the colony are actually, during life, dependent on one another; and whether the normal duration of life of the colony is or is not simply that of the oldest polypes, are questions which, though of great interest, we cannot yet answer with any certainty. Concerning the first of these we may, however, note that the smallest zooids have no mouths, and therefore must be absolutely dependent for nutriment on the supply brought to them by the canal system from the polypes and the larger zooids; while as regards the latter question it is certainly worth noticing that in each of the specimens of *Funiculina* taken alive all the polypes and zooids were living and healthy; no dead or diseased individuals being seen.

The endoderm of the body-wall is a single layer of rather long columnar cells. In many places these are distinctly ciliated, and it is probable that the ciliation really extends over the whole surface. The endoderm, as just noticed, lines the larger canals of the mesoderm, passing into them at the points where they open into the body-cavity; here also it is ciliated, and it is probable that to these cilia are mainly due the currents which in the living animal undoubtedly pass along these canals.

Between the mesoderm and endoderm is, as usual among *Actinozoa*, a system of muscular bands. These are, however, only very feebly developed in the body-wall of *Funiculina*: they consist of—(1) *longitudinal fibres*, whose direction corresponds with the length of the polype, and which will be noticed again when the mesenteries are described, and (2) *circular fibres*, which run transversely round the body-wall: these are but slightly developed; they do not form a continuous sheath as in most *Actinozoa*, but occur as irregular bands, usually not extending round more than three-fourths of the circumference of the body-wall.

The body-wall is thickest below, at its junction with the rachis, and gradually diminishes in thickness as it passes upwards, the alteration affecting the mesoderm only. Owing to the stiffness of this semi-cartilaginous mesoderm the polype body is non-retractile, a point that distinguishes *Funiculina* from *Pavonaria* and other allied genera, and one which is clearly correlated with the very feeble development of the muscular system just noticed.

b. The Calyx.—The calyx with its pointed processes forms a kind of low wall surrounding the bases of the tentacles when these are fully expanded, as in Fig. 7; but when the tentacles are retracted, the pointed processes of the calyx are pulled in slightly towards one another, as shown in some of the polypes of Fig. 3, and so serve to partially close and protect the entrance to the polype-cavity. The structure of the calyx is very similar to that of the body-wall, of which indeed it is only the uppermost portion. Each of the eight pointed processes into which it is produced (Fig. 7) is hollow, its cavity (Figs. 10 and 12 *h*), which is lined by endoderm, communicating somewhat obliquely with the body-cavity. In their upper portions these cavities, like the processes in which they are contained, are situated between the tentacles, as shown in the transverse section drawn in Fig. 12; but the lower portions pass obliquely downwards, so as to open opposite the cavities of the tentacles into the chambers between the mesenteries. In Fig. 10 the plane of section passes on the left side of the figure between two of the tentacles, and therefore along the middle of one of the pointed processes of the calyx, the cavity of which is seen in the upper part of the process; on the right hand side of the figure the section passes down the middle of a tentacle and through the opening of the cavity of a calyx-process into the body-cavity of the polype.

Each of the calyx-processes is stiffened by one or more calcareous spicules of a very curious shape. These are shown *in situ* in Fig. 7 (*i*) and in Fig. 12, in which latter they are seen cut transversely. Each spicule is a calcareous rod (Fig. 8) about 0·02 inch long, and 0·0009 inch diameter: in transverse section it is, as shown in Fig. 9, triradiate with thickened edges. This triple-ribbed form, which is clearly shown in the figures referred to, and which appears to have escaped notice hitherto, is singularly appropriate from a mechanical point of view, forming an admirable combination of lateral strength with lightness of material. Similar spicules, though usually somewhat smaller, are sometimes found in the upper part of the body-wall (Fig. 7).

The calyx and its processes are devoid of muscles, even the feeble muscles of the body-wall ceasing below the calyx, so that the slight approximation of the points which occurs when the tentacles are retracted must be effected simply by the muscles attached to the bases of the tentacles, the arrangement and mode of action of which we shall notice when describing the mesenteries.

c. The Tentacles are eight hollow * prolongations of the body-wall surrounding the mouth, and fringed on each side by a row of hollow pinnules, usually nine or ten in number. The general characters of the tentacles and their pinnules are shown in Plate I., Fig. 3, and Plate II., Fig. 10, and the microscopic structure in Plate II., Fig. 11, the latter figure representing a transverse section across a tentacle taken about the middle of its length and passing through the base of one of the pinnules.

* Forbes incorrectly describes the tentacles as solid. *Vide* Johnston: "British Zoophytes," 2nd Ed., 1847, p. 166.

The tentacles and pinnules being, as before stated, prolongations of the body-wall, consist, like it, of ectoderm, mesoderm, and endoderm; but the intimate structure and relative proportions of the three layers differ very considerably from those we have found to obtain in the body-wall.

The ectoderm (Fig. 11 *w*) is the thickest of the three layers: in it the outlines of the component cells are very difficult to make out, and it is only in the most favourable specimens that this can be done with any certainty. The individual cells are long, thin, and columnar, ciliated at their free ends, and arranged in a single layer, each cell extending through the whole thickness of the ectoderm: in the deeper parts of the ectoderm, between the bases of these columnar cells, smaller cells of a spherical or fusiform shape occur, but in no great number.

Imbedded in and between the ectoderm cells are very numerous thread-cells or nematocysts (Fig. 11 *z*), the characteristic weapons of the *Cœlenterata*. Each of these is a capsule of an elongated oval shape, and about 0·0004 in. long, within which is contained a long spirally-coiled hollow thread, visible in many of our specimens when examined with sufficiently high powers ($\frac{1}{8}$th or $\frac{1}{15}$th in.) In the Sea-anemones, and in the common fresh water *Hydra*, in which similar thread-cells occur, any external irritation, such as contact with a foreign body, causes the thread to be shot out from the capsule with great force and rapidity, penetrating the irritating body, and exercising on it, if an animal, an instantaneous numbing or paralysing action.* We had no opportunity of testing their action in the living *Funiculina*, but there can be no doubt that it is the same as in the anemones and *Hydra*.

In the tentacles of *Funiculina* the thread-cells (Fig. 11) are most abundant close to the surface, where they are closely packed side by side, with their outer ends just beneath the surface, and their long axes perpendicular to it; large numbers also occur in the deeper parts of the ectoderm. In shape and mode of arrangement the thread-cells of *Funiculina* agree very closely with those of *Sagartia troglodytes*, as described and figured by Heider,† and with those of the anemones generally, as described by the brothers Hertwig‡; the thread-cells of *Hydra* are larger and much more globular in shape.

The mesoderm, which is the thinnest layer of the three, consists almost entirely of muscles; a very powerful external layer of longitudinal muscles, seen cut across in Fig. 11, and an inner less powerful layer of circular muscles. By these muscles the movements of the

* For a very complete and admirable account of these thread-cells and their mode of action in sea-anemones, *vide* Gosse: "British Sea-anemones and Corals, 1860," pp. xxix-xl.

† *Heider*. Sagartia troglodytes. Sitzb. der K. Akad. der Wissensch. z. Wien. Bd. lxxv. 1877, pp. 22-24; and Plates III., IV., and VII.

‡ Oscar und Richard Hertwig: Die Actinien. 1879.

tentacles in the living animal are effected, and also, in part, the retraction of the tentacles when disturbed.

The endoderm does not differ markedly from that of the body-wall: it consists of a single layer of columnar cells, often swollen at their inner ends. In the cavities of the tentacles, the size of which varies much with the extent to which the tentacles are expanded, very numerous spherical nucleated cells occur: these are always in close contact with the endoderm cells, but whether they properly belong to the endoderm or not we have been unable to determine. They may perhaps be described as mucus cells.

The pinnules have the same structure as the tentacles. Each is hollow, its cavity opening into that of the tentacle (Figs. 10 and 11), and its wall consisting of ectoderm, mesoderm, and endoderm, having the same structure and proportions as in the tentacles, differing only in being of less thickness.

d. The Stomach.—The mouth is not circular, but, as in the majority of *Actinozoa*,* a transverse slit. The section drawn in Fig. 12, though taken a short distance below the mouth, shows this character very well. The direction of the axis of the mouth, which is a constant one, we shall refer to after considering the arrangement of the mesenteries.

The mouth leads by a short œsophagus into the stomach (Fig. 10 *n*), the walls of which are thrown into transverse folds, as shown in the figure: these folds become much more marked when the tentacles are retracted, the whole stomach being then shortened by the approximation of the folds, somewhat after the manner of a concertina, and thus providing space within the calyx in which the retracted tentacles are lodged. At its lower end the stomach opens into the body cavity by a slit-like orifice, the direction of which corresponds to that of the mouth.

The stomach-wall consists (Fig. 10) of (1) an inner lining membrane which at the margin of the mouth becomes continuous with the external ectoderm, and is therefore described as ectoderm; (2) of a thin mesoderm; and (3) of an outer layer or endoderm continuous with that of the tentacles and of the body-wall.

The ectoderm (Figs. 10 and 13, *w*) is a thick layer, consisting of much elongated columnar ciliated cells, between which are other elongated cells with a very granular appearance, and probably of a glandular nature: at the inner or free surface are seen at intervals what appear at first sight to be clear spaces, but which are almost certainly cells similar to those described in Anemones by the Hertwigs as mucous cells.† The deepest or outermost part of the ectoderm contains fusiform and spherical cells imbedded between the bases of the longer ciliated and glandular cells.

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* *Vide* Gosse; Heider, etc., *op. cit.*

† O. und R. Hertwig: *Op. cit.*, pp. 58-60, and Taf. III., Fig. 6, where the two kinds of gland-cells, viz., granular and mucous, are described and figured.

The mesoderm of the stomach (Figs. 10 and 13, *x*) is a very thin fibrillated layer of connective tissue, in which we have not detected any definite muscular bands. We have found no traces of sphincter muscles round either the mouth or the lower aperture of the stomach.

The endoderm (Figs. 10 and 13 *y*) is chiefly characterised by containing an enormous number of extremely minute and highly refractive particles, which completely conceal the outlines of the endoderm cells. These particles, seen singly, appear of a pale yellowish-brown colour; but, in quantity, impart a deep brown or even black colour to the endoderm of the stomach, which is very evident in all the specimens. Concerning the use of these granules we have no evidence whatever. They appear to be the same things described by Gosse,* in *Actinoloba*, *Tealia*, *Peachia*, *etc.*, as "a nearly uniform mass of yellow fat-cells," and as hepatic in function. We much doubt the correctness of either of these statements. It has been shown that in allied forms these granules are insoluble in ether, and are therefore not fat; and concerning their supposed digestive functions, it must be noted that they are confined to the endoderm cells, and never, so far as our observations go, occur in either the mesoderm or ectoderm of the stomach, so that they could only act on food not in the stomach, but in the compartments of the body-cavity outside it, a position in which it is very doubtful whether food is ever found. Moreover, we shall find shortly that it is very doubtful whether digestion, at any rate of animal matter, is really effected in the stomach at all, as supposed by Gosse. And, finally, we would notice that the granules in question are very closely similar to, if not indeed identical with, the brown granules already described as occurring in the deeper parts of the ectoderm cells of the body wall.

e. The Mesenteries.—These are the eight vertical partitions or septa which connect the stomach to the body-wall, and so divide the body-cavity round the stomach into a series of compartments; below the stomach they extend, as previously noticed, to the bottom of the body-cavity.

Each mesentery consists (Figs. 10, 13, 16, and 15 *o*) of a thin central mesodermal plate, clothed on each side by endoderm.

The endoderm (*y*) is very similar to, but slightly thinner than, that lining the body-wall, with which it is directly continuous. It consists of a single layer of short columnar cells, which contain, especially near the stomach, granules of the same character as those just described in the endoderm of the stomach.

The mesoderm is a thin connective tissue lamella, continuous on the outer side with the mesoderm of the body-wall, and on the inner side with that of the stomach. Between the connective tissue lamella and the endoderm covering it, is a well-developed system of muscles, the most powerful of which form the great retractor muscles of the

* Gosse: *Op. cit.*, Introduction, p. xvii.

polype (Fig. 10 *p*), by which the stomach can be drawn down, and the tentacles pulled back within the calyx.

Each retractor muscle, as shown in Fig. 10, extends the whole length of the septum to which it belongs. Arising from the body-wall along the whole length of the base of attachment of the septum, the fibres pass up in bundles in the substance of the septum, and are inserted mainly into the walls of the stomach, especially its upper part, and partly into the bases of the tentacles and the parts immediately around the mouth. Below the stomach each retractor muscle (Figs. 10 and 14 *p*) does not extend over the whole width of the septum, but is confined to its outer half.

The transverse sections drawn in Figs. 13 and 14 show some further points of importance concerning these muscles. They show, firstly, that the retractor muscles, which lie between the mesoderm (*x*) and endoderm (*y*) do not lie on both sides of the septa, but only on one side of each. A more important point, shown clearly in the figures referred to, is that the muscles do not lie on the same side of all the septa. Thus, on the left hand side of Figs. 13 and 14, is a compartment of the body-cavity, bounded by two mesenteries in which the retractor muscles face away from one another; while on the right hand side of the figures is one in which the retractor muscles face towards one another. In the intermediate septa, whether above or below the stomach in the figures, the retractor muscles are all on the right hand side of the septa.

Owing to this arrangement it is seen at once that there is only one possible bisecting plane that will divide the polype longitudinally into two perfectly symmetrical halves, *i.e.*, a plane passing through the middle of both the right hand and the left hand compartments; or in Plate II., a plane indicated by a horizontal line drawn across the middle of the figures in question.

This *plane of symmetry*, as is shown in Figs. 12 and 13, is also the one which passes through the long axis of both the mouth and the opening from the stomach to the body-cavity, and is the plane of bisection adopted in Fig. 10.

A less important point, shown by the sections in Figs. 13 and 14, is that the longitudinal muscles extend a short distance round the body-wall on either side of the lines of attachment of the septa, forming, by so doing, the system of longitudinal muscles of the body-wall referred to on a preceding page.

Besides the large retractor muscles there is in the upper part of the polype a second much weaker set of muscles crossing the former at right angles, and having an antagonistic action. These protractor muscles (Fig. 10 *q*) arise from the upper part of the body-wall, and from the calyx, run downwards and inwards in the septa, and are inserted into the mesoderm of the stomach wall. Their action is to pull up the stomach after it has been drawn down by the retractors.

f. The Mesenterial Filaments.—These, as stated above, are the thickened convoluted free edges of the mesenteries below the stomach (Figs. 10 and 14, *r* and *s*). They are of two kinds:—(1.) A set of two (*s*), which are much more slender than the others, but much longer, extending to the bottom of the body-cavity: these we shall refer to as the *long mesenterial filaments*. (2.) A set of six (Figs. 10 and 14 *r*), which are much thicker and more convoluted, but also much shorter, only extending about half-way from the lower end of the stomach to the bottom of the body-cavity: these are the *short mesenterial filaments*.

In the sections drawn in Figs. 13, 14, and 15, the septa bounding the left hand compartments are those which bear the long mesenterial filaments, so that the plane of symmetry, as defined above, passes between them, and therefore divides the mesenterial filaments, as it divides the retractor muscles and the stomach, into two perfectly symmetrical halves.

The structure of the mesenterial filaments is shown in Figs. 10 and 14: each is a single band, although, owing to its convolutions, it may be cut more than once in a single transverse section (Fig. 14). Each filament consists of a central mesodermal connective tissue lamella, continuous with that of the septum, and clothed by a thick layer of endodermal cells of a special character. These cells are of two chief kinds:—(1.) Columnar ciliated cells; and (2) large granular gland-cells. These latter are very numerous, and give the special character to the filaments. Numerous spherical nucleated cells, similar to those described as occurring in the cavities of the tentacles, are found lying in contact with the endoderm cells, and apparently belonging to them (Fig. 14.)

The structure of the long mesenterial filaments is very similar to that of the short ones; the endoderm is, however, distinctly thinner, and the gland cells not so numerous relatively to the ciliated cells.

Notwithstanding very careful examination, we have failed to detect thread-cells in the mesenterial filaments of *Funiculina*. From the descriptions of Gosse, Heider, the Hertwigs, etc., thread-cells appear to be present in the mesenterial filaments of all other *Actinozoa* that have been examined hitherto, so that if they be really absent in *Funiculina* the point would be important. It is, however, a difficult matter to establish a negative, especially in histology; and bearing in mind the facts that our specimens were neither examined perfectly fresh, nor were prepared for the purpose of histological examination, we can merely record that we have failed to find them. There is, perhaps, no point on which we have more reason to regret the imperfect histological condition of our specimens than the present one, for the presence of thread-cells in the mesenterial filaments, *i.e.*, endoderm, of *Actinozoa* in general, has always been a great difficulty to morphologists, who are inclined to view thread-cells as belonging properly to the ectoderm only, so that their absence from the endoderm of *Funiculina*, should it prove to be a real and constant one, would become a point of much interest and importance.

Gosse, in his account of the mesenterial filaments of the Sea-anemones,* describes them as of two kinds, which he distinguishes by the names of *craspeda* and *acontia*, assigning the former name to the thickened cord-like edges of the mesenteries, and the latter to certain spirally-twisted threads similar in structure to the *craspeda*, and attached to them by one end, but with the greater part of their length lying freely in the body-cavity, and capable of being shot out through special apertures (*cinclides*) in the body-wall. From the description given above, it is evident that *Funiculina*, to use Gosse's nomenclature, has *craspeda*, but no *acontia*. Heider† and others have indeed doubted whether Gosse's *acontia* really exist in the Sea-anemones.

Concerning the function of these mesenterial filaments there has been so much dispute that a few words may not be out of place here, although the subject is one which we have had no opportunity of investigating physiologically in *Funiculina*, and which, therefore, does not, strictly speaking, fall within the limits of the present report.

By different writers all possible functions appear to have been assigned to these organs. Contarini, Delle Chiaje, Spix, Johnston, Wagner, and Owen, describe them as the male reproductive organs, either essential or accessory; by Rapp, Cuvier, R. Jones, and Quatrefaga, they were regarded either as ovaries or oviducts; others have considered them to be bile vessels; while Frey, Leuckart, Schmarda, and more recently Heider and the Hertwigs, are of opinion that as they contain both gland-cells and thread-cells their main function is probably that of digestive organs, the thread-cells serving to paralyse or kill the prey after being swallowed alive, and the gland-cells to digest it when dead.

By far the most important evidence on the subject, however, is that submitted by Dr. Krukenberg‡ as the result of a direct physiological investigation of the action of the mesenterial filaments of Sea-anemones. He finds that the mesenterial filaments have a very considerable power of digesting albuminous substances, such as raw fibrin or raw pieces of flesh; and by mixing portions of the filaments with small pieces of raw meat in a very finely-divided state, he was able to watch the process of solution, *i.e.*, digestion of the meat under the microscope. Furthermore, by experimenting in a similar manner with portions of the stomach, tentacles, body-wall, etc., of the Anemone, he was led to the important conclusion—that not only have the mesenterial filaments the power of digesting albuminous bodies, but that they are the only portions of the body which possess this power: that they are not only digestive organs, but *the* digestive organs of the Anemone so far as proteid matters are concerned.

* Gosse, *op. cit.*, Introduction, pp. xxiii-xxix.

† Heider, *loc. cit.*

‡ Krukenberg: "Vergleichend physiologische Studien an den Küsten der Adria." Erste Abtheilung, 1880, pp. 38-56. "Ueber den Verdauungsmodus der Actinien." For a knowledge of this interesting and important paper we are indebted to Professor Ray Lankester.

For digestion to take place it is necessary for there to be absolute contact between the gland-cells of the filaments and the food; from which Dr. Krukenberg concludes that digestion is not effected by means of a fluid secretion poured out over the food, but by the direct action of the cells themselves. Watery or glycerine extracts of the mesenterial filaments of *Sagartia* or *Anthea* are found to digest fibrin rapidly at a temperature of 100°-105° F.

From the above account, which we have quoted because it is the only one based on direct physiological experiments, and also because it appears to be as yet but little known in this country, there can no longer be any doubt as to the function of these hitherto mysterious mesenterial filaments.

g. The Reproductive Organs. The sexes among the *Pennatulida* are distinct so far as is as yet known, the polypes of each individual Sea-pen being either all male or all female.* Of the specimens of *Funiculina* obtained living at Oban the two larger ones, which alone have been examined for the purpose, are both females, a circumstance we much regret, inasmuch as no description of a male *Funiculina* has yet appeared; the statement that the sexes are distinct resting merely on the analogy furnished by allied genera such as *Halisceptrum* † and *Pennatula*,‡ and on the fact that in the female specimens described, *all* the polypes examined bore eggs. As we shall find when dealing with the historical portion of our subject, only a very limited number of specimens of *Funiculina* have yet been examined with any care, so that it is hardly safe to generalise concerning the apparent rarity of male specimens; but it may well be that the male pens are either really less numerous than the female, or else that they are as a rule smaller, and therefore disregarded. We trust that the Society will on some future occasion be able to determine this point.

The ovaries of *Funiculina* (Figs. 10 and 15) are the free edges of the six mesenteries which bear, higher up, the short mesenterial filaments. The ova, or eggs (*t*), are developed as little prominences attached by short stalks to the edges of the mesenteries, from which, when ripe, they become detached, and then lie free in the body-cavity, as shown in Fig. 10.

Each ovum is apparently a single endodermal cell, which becomes bigger than its neighbours, and so projects above the surface of the ovary: each is, from a very early period, enclosed in a thin capsule, very similar in appearance and in behaviour with staining fluids to the connective tissue mesodermal lamella of the mesentery; though whether it is actually developed from this lamella, as maintained by the Hertwigs § in the case of the Anemones, we have not

* Kolliker: *Op. cit.*

† Kolliker: *Op. cit.*, pp. 147-172, and Plate XI., Fig. 95, Plate XII., Fig. 94.

‡ An account of the male *Pennatula*, of which no description has hitherto been published, is given in the second part of this Report.

§ O. und R. Hertwig: *Op. cit.*

been able to determine. Later on each egg becomes invested by a second outer capsule, which is much thicker than the first, is clearly derived from the endoderm cells surrounding the ovum, and contains numerous minute pigment granules very similar in appearance to those in the endoderm of the stomach. This outer capsule has its surface, in the fully-developed egg, raised into a series of low ridges, forming an irregular surface pattern.

Each egg has from its earliest appearance a very large and conspicuous *nucleus* or germinal vesicle, containing one and sometimes two *nucleoli* or germinal spots. The germinal vesicle, which increases greatly in size with the growth of the egg, consists of a tough, elastic, and fairly thick membrane, with clear, apparently fluid, contents : it lies adjacent to the stalk of attachment of the egg, and in many cases projects into this stalk for a short distance. The nucleolus is spherical, of a yellowish colour, and distinctly granular.

The average diameter of the mature eggs is 0·014in.,and the thickness of the capsule 0·001 in. : while the germinal vesicle, which is usually oval, measures 0·003 in. by 0·002 in.

Whether fertilisation and the early stages of development are, as is most probable, effected within the body-cavity of the parent we have had no opportunity of determining. In no case have the eggs in our specimens commenced to develope ; indeed the germinal vesicle is still present and unaltered in every one of the eggs we have examined.

We have not observed a micropyle, though from the thickness and toughness of the egg capsule it is not improbable that one exists.

Eggs sometimes occur within the cœnenchymal canals, as is shown in the lower part of Fig. 10. The eggs so found are usually either fully developed ones, or else eggs that are very nearly mature. As we have noticed several instances of this we are inclined to view it as a normal condition, though how the eggs get into the canals, whose diameter is much smaller than that of the mature eggs, and still more how they get out again, is far from obvious. It may be that the eggs are accidently dislodged when young and carried with the nutrient matter into the canals, where they remain, and, receiving a plentiful supply of food, grow.

Besides the sexual process of reproduction there can be but little doubt that *Funiculina* can multiply asexually by gemmation or budding ; this asexual process serving, as in other colonial *Cœlenterata*, to increase the number of individuals in the colony, whilst it is by the sexual process alone that new colonies can be started.

5. *Anatomy of the Zooids.*—

The only important points in which the zooids differ from the polypes are the following :—

1. They have no tentacles, and no distinct calyx.
2. They have only two mesenterial filaments, viz., those corresponding to the two long filaments of the polypes : like these latter they

extend to the bottom of the body-cavity. The remaining six mesenteries are present, but their free edges below the stomach are not thickened to form mesenterial filaments.

3. They have no reproductive organs.

Whether these distinctions are absolute is, however, very uncertain. In the younger specimens there appears to be a gradual passage from zooids to polypes (Fig. 6), though whether zooids are in all cases destined ultimately to grow up into polypes must be left for the present undecided.

Polymorphism, *i.e.* the existence of structural differences between individuals living together and fundamentally alike, is very widespread, and attains a high degree of development among *Hydrozoa*, where we commonly find in a single colony (*a*) nutritive individuals with mouths and tentacles, which digest food not only for themselves, but for the rest of the colony as well, but are often destitute of means for capturing their prey; (*b*) prehensile individuals, richly provided with thread-cells, capturing the prey and conveying it to the nutritive individuals to be digested, but themselves destitute of mouth or stomach; (*c*) reproductive individuals, often with no mouth or stomach. To these may be added, in many cases, locomotive individuals, whose sole function is to propel the colony through the water; protective individuals, and a variety of other forms.

Among *Actinozoa*, on the other hand, though we have an equally marked tendency to the formation of colonies by budding, polymorphism is exceedingly rare, all the individuals composing the colony being as a rule alike: the most marked examples of polymorphism are shown by the group with which we are now dealing—the *Pennatulida*—and even here we only meet with two kinds of individuals, the polypes and the zooids, between which the distinction may be as in *Funiculina* by no means an absolute one.

Zoological Position and Affinities.

The general zoological position of *Funiculina* is shown in the Table given on page 1 of this Report. The generic characters, as given by Kölliker, our greatest authority on the group, are as follows:—*

"Genus: *Funiculina*. Long slender Sea-feather; stalk short, with no conspicuous dilatations; polypes inserted directly into rachis; stem quadrangular. Polypes protruding from long cups whose margins are produced into eight pointed processes, each of which contains in its interior a prolongation of one of the body compartments surrounding the stomach, and in its walls longitudinal series of long slender calcareous needles which extend a certain distance down the cups and end in a number of oblique and transversely placed needles. Polypes in obliquely placed rows on the dorsal angles and adjoining sides of the rachis: tentacles with no calcareous needles. Zooids of same form as polypes lying on dorsal surface of rachis nearer the middle line than

* Kölliker, *op. cit.*, p. 250.

the sexual animals: at the lowermost end of the feather the zooids take the place of the polypes and end in single rows on the lateral surfaces of the rachis. Sexual organs in the body-cavities of all adult polypes. Radial nutrient canals not present. Integument of both rachis and stalk beset with calcareous needles, especially abundant in the stalk."

Kölliker only recognises a single species, viz., *Funiculina quadrangularis*. He gives the following list of synonyms and definition of the species:—*

Synonyms.—*Penna del pesce pavone.* Bohadsch.
Pennatula quadrangularis. Pallas.
Pennatula antennina. Linnæus, Ellis, and Solander.
Funiculina tetragona. Lamarck.
Pavonaria Antennina. Cuvier, Schweigger, Ehrenberg.
Pavonaria quadrangularis. Blainville, D. Chiaje, E. Forbes, Johnston, M. Edwards.
Funiculina antennina. V. D. Hoeven.
Funiculina Forbesii. Verrill.
Funiculina quadrangularis. Herklots.

Definition of Species.—"Colony up to 53 inches long, and at its widest part 0·4 to 0·5 inch breadth. Feather five to six times as long as stalk. Polype cups cylindrical, forming a conical pointed end when closed, very numerous, arranged in oblique rows or clusters on the dorsal angles and neighbouring parts of the dorsal and lateral surfaces; the larger polypes 0·2 to 0·4 inch long. The pointed processes of the cup-border (calyx) up to 0·02 inch long. Prolongations of the body-cavity into the cup-border (calyx) 0·05 to 0·06 inch long. Calcareous needles of the cup up to 0·024 to 0·028 inch long."

By Verrill, as we have already seen, two species of *Funiculina* were distinguished, the name *Funiculina Forbesii* being proposed for the Scotch specimens, to distinguish them from the Mediterranean ones. We have in a former section of this Report fully explained the reasons which have led us to reject this division.

Dr. Gray describes three species of *Funiculina*:†—*Funiculina quadrangularis, F. Forbesii, and F. Philippinensis.* Concerning the two first of these species the distinction is that proposed by Verrill, which we have found is not valid. Concerning the third species all that Dr. Gray tells us is the following:—

"3. *Funiculina Philippinensis.* B.M.
Axis quadrangular, about a foot long.
Hab. Philippines (Cuming)."

Kölliker makes no reference to it, although his monograph is of later date than Dr. Gray's catalogue; and on inquiry at the British Museum we find that the specimens are no longer in existence.

* Kölliker, *op. cit.*, p. 256.
† Gray: "Catalogue of the Sea-Pens or Pennatulariidæ in the collection of the British Museum." 1870, pp. 12—13.

If no mistake has been made, this species, concerning which, in the absence of any specimens, we must feel doubtful, is of considerable interest as coming from an otherwise unrecorded locality.

HISTORY AND LITERATURE.

We propose under this heading to give as complete a list as we have been able to compile of the descriptions and figures of *Funiculina* published hitherto, arranged according to date of publication. We have purposely omitted references to works on systematic zoology, in which *Funiculina* is merely mentioned in its proper zoological position, but have included all original works and papers bearing on the subject with which we are acquainted. We have indicated by an asterisk all works to which we have not been able to refer directly.

*1761.—*Bohadsch*: "*De quibusdam Animalibus Marinis*," p. 112, and Plate IX., Figs. 4 and 5. Contains description and two figures of the first recorded specimen of *Funiculina*, discovered by himself at Naples in 1757. This specimen was, according to Bohadsch, 34ins. long, but broken at the lower end. He notices the quadrangular shape of the stem, also that the polypes cover three-fourths of the upper part of the rachis, but leave the fourth side bare. The polypes were 1,310 in number, and are noted as being non-retractile.

1764.—Ellis: "Philosophical Transactions." vol. liii. pp. 423-425. Translates part of Bohadsch's description, and copies, on Plate XX., Fig. 8, one of his figures on a scale one-third the natural size. This figure has also been copied by Blainville.

*1766.—Pallas: "*Elenchus Zoophytorum*." Assigns the name *Pennatula quadrangularis* to Bohadsch's hitherto un-named specimen.

1786.—Ellis and Solander: "Natural History of Zoophytes," pp. 63-64. Refer to Bohadsch's specimen, which appears to be the only one described up to that date, under the name *Pennatula antennina*, given it by Linnæus.

1844.—Edward Forbes: "Annals and Magazine of Natural History," vol. xiv., pp. 413-414. Describes the capture of the first British specimens of *Funiculina*; the first indeed recorded from any locality other than Naples. The specimens, which were dredged by Mr. MacAndrew, were obtained, "both dead and alive, in twenty fathoms water, off the island of Kerrera, near Oban, the bottom being mud, in which it doubtless stands erect, after the manner of *Virgularia*." One of the specimens, 30ins. in length, was exhibited at the Natural History Section of the British Association at the York Meeting in 1844.

1847.—Edward Forbes, in "Johnston's British Zoophytes," 2nd ed., vol. i., pp. 164-166, mentions obtaining specimens of *Funiculina*, the largest of them 4ft. long, in twelve to fifteen fathoms of water, "near Oban, but nowhere else:" describes them as rose-coloured, when living, and brilliantly phosphorescent. In vol. ii., Plate XXXI., Figs. 1—7, he gives seven figures of *Funiculina* from his own drawings. These, which are the only figures yet published of British specimens, give a fair general idea of *Funiculina*, but are in many respects exceedingly inaccurate.

1851.—Kölliker: "Zeitschrift für wissenschaftliche Zoologie," Bd. iii., p. 91, in a letter to Siebold, mentions obtaining, while in Scotland, a specimen, 3ft. long, which he took back with him to Würzburg, and which, he remarks, was probably the first specimen ever seen in Germany.

1855.—Gosse: "Manual of Marine Zoology," Part I., p. 35, Fig. 55. Copies on a reduced scale two of Forbes' figures given in "Johnston's Zoophytes."

1856.—Sars, Koren, and Danielssen: "*Fauna littoralis Norvegiæ*," Andet Hefte, pp. 73 and 92. Mention the capture of a specimen, 4ft. long, at Eisvaag, in the Fiord of Bergen, in 100 fathoms of water, and note that this was the first, and up to the date of publication, the only specimen obtained from the Scandinavian shore.

*1858.—Herklots: "Noticees pour servir à l'étude des Pennatulides, Bijdragen, tot de Dierkunde, Amsterdam." p. 8. We have been unable either to consult this work or even to obtain any second-hand account of its contents as regards *Funiculina*. As the reference is merely to a single page, it can hardly contain any anatomical account.

1860.—Gray: Revision of the family *Pennatulidæ*. "Annals and Magazine of Natural History," p. 20.

1864.—A. E. Verrill: List of the Polypes and Corals sent by the Museum of Comparative Zoology to other institutions in exchange, with Annotations; published in the "Bulletin of the Museum of Comparative Zoology," at Harvard College, Cambridge, Mass., p. 30. Describes Scotch specimens obtained from Mr. Stimpson as of a distinct species (*F. Forbesii*) from the Mediterranean one.

1869—Richiardi: "Monografia della Famiglia dei Pennatularii: Bologna," pp. 89-95. Disputes the accuracy of Verrill's distinction, stating that he has obtained from the Mediterranean complete series of specimens leading from Verrill's *F. Forbesii*, which he considers merely a young form, to the typical *F. quadrangularis*. Gives on Plate XII., Figs. 95 and 96, a very imperfect and greatly reduced figure in two halves of the adult *Funiculina*.

1870.—Gray: "Catalogue of the Sea-Pens or Pennatulariidæ in the Collection of the British Museum," pp. 12-13, adopts Verrill's species (*F. Forbesii*), and proposes a classification of his own, which has not met with acceptance.

1872.—Kölliker: "Anatomisch-systematische Beschreibung der Alcyonarien. Erste Abtheilung: Die Pennatuliden." In this extremely important and copiously-illustrated work a very full description of the anatomy of *Funiculina*, the only one that has yet appeared, is given on pp. 250-261, and an excellent series of figures, all original, on Plates XVI., XVII., and XVIII., Figs. 145, 148—154. These figures show an entire young specimen of the natural size; enlarged views of various portions of the feather, showing the arrangement of the polypes and zooids; and more highly magnified views of transverse sections of the whole rachis and of a portion of the stalk. All the drawings are, however, unfortunately taken from specimens in which the tentacles are completely retracted, and consequently do not represent correctly the appearance of the polypes in the living state. In the letterpress, besides the anatomical description, there is a very complete bibliography, and a list of all the specimens and localities known to exist at the date of publication.

We are indebted to this work for many of the details incorporated in the present report.

1873.—Sir C. Wyville Thomson: "Depths of the Sea," pp. 149 and 178, describes dredging *Funiculina* in about 100 fathoms of water in Raasay Sound, along the east coast of the Isle of Skye. The specimens from this new locality were obtained on September 13th, 1869, during the third cruise of H.M.S. "Porcupine." Their capture is described thus: "The *Pavonariæ* (*Funiculinæ*) were resplendent with a pale lilac phosphorescence like the flame of cyanogen gas; not scintillating like the green light of *Ophiacantha*, but almost constant; sometimes flashing out at one point more brightly, and then dying gradually into comparative dimness, but always sufficiently bright to make every portion of a stem caught in the tangles or sticking to the ropes distinctly visible. From the number of specimens of *Pavonaria* (*Funiculina*) brought up at one haul we had evidently passed over a forest of them. The stems were a metre (about 39ins.) long, fringed with hundreds of polypes."

We learn from Professor Herdman that during the third cruise of the "Porcupine" *Funiculina* was dredged at one other locality besides the one just mentioned. Among the "Porcupine" stores is a bottle containing one specimen of *Funiculina*, eight inches long, and with the following label: "Porcupine, No. 54, 19-8-69. 363 fathoms. Bottom, stony." From the map illustrating the third cruise of the "Porcupine,"* and from the tables giving the positions, etc., of the several dredging stations† we find that station 54, this new locality for *Funiculina*, is in latitude 59° 56′ N., and longitude 6° 27′ W., about midway between the island of Lewis in the Hebrides, and Suderöe the southernmost of the Faröe Islands, and in very nearly the same latitude as Bergen. This locality is of considerable interest for many reasons: it is the most northerly British locality recorded; the depth (363 fathoms) is the greatest from which living specimens have ever been obtained: the bottom temperature was very low, 31·5° F.; and the bottom stony instead of as in other localities mud. An additional point of interest lies in the fact that while all other recorded localities are either in land-locked channels, or else close to the mainland, this is in the open ocean.

1880.—Kölliker: "Report on the Pennatulida dredged by H.M.S. 'Challenger': Zoology of 'Challenger' Expedition," Part II., p. 34. Gives a new classification of the Pennatulida, in which the zoological position and affinities of *Funiculina* are determined. No specimens of *Funiculina* were obtained by the "Challenger" during the whole of her three years' cruise: but two new allied genera were discovered, of which one genus, *Stachyptilum*, is represented by a single specimen from the west coast of New Guinea; while of the other genus, *Anthoptilum*, three species were discovered, two in the South Atlantic Ocean, one of them near Buenos Ayres, and the other near the oceanic Islands of Tristan d'Acunha, and the third in the North Atlantic, near Halifax, in Nova Scotia.

Geographical Distribution.

Funiculina has a very limited distribution indeed; the only localities recorded hitherto being the following:—

A.—*Mediterranean:*

1. Naples, where it was first discovered in 1757.

* Thomson: "Depths of the Sea," Plate IV., p. 106. † *Ibid.*, p. 143.

2. Adriatic Sea. The canal of Novi in Dalmatia is mentioned by Kölliker as a locality from which the natural history dealer, Fric, of Prague, obtained several specimens, the largest measuring 50 ins. long.

B.—*Scotland :*

3. Oban, off the Island of Kerrera. First discovered by MacAndrew in 1844. Largest recorded specimen mentioned by Forbes as 48ins. long.

4. Raasay Sound. Discovered by Thomson during the dredging cruise of the "Porcupine," 1869. Loch Torridon, near Raasay Sound, is mentioned as the locality whence the specimen, 53 ins. long, in the Newcastle Museum (*vide infra*) was obtained.

5. A spot in the North Atlantic in lat. 59° 56′ N., and long. 6° 27′ W.; Station 54 of the third cruise of the "Porcupine," 1869, under Sir W. Thomson.

6. Hebrides. Mentioned, without further particulars, by Kölliker as a locality whence MacAndrew obtained specimens.

C.—*Scandinavian Shores :*

7. Bohuslän, in the Kattegat. Largest specimen 53ins. long.

8. Eisvaeg, in the Fiord of Bergen.

9. Glaesvae, in the Fiord of Bergen. The largest recorded specimen, a dead stem upwards of 7ft. long, was obtained from here.

10. Danish Coast. Mentioned without further particulars by Kölliker as a locality.

Not only is the geographical distribution of *Funiculina* a very limited one, but wherever it does occur it seems to be confined to a very small spot, in which it occurs fairly abundantly ; as we infer from the facts that (1) in Raasay Sound, although Thomson found it once only, yet he then dredged it "in quantity." (2) That *Funiculina* is included in the catalogues of duplicates for sale or exchange published by both Dr. Dohrn, of Naples, and Dr. Malm, of Göteborg in Sweden.

As to limits of depth we have no very certain knowledge. The Oban specimens were found at depths from 12 fathoms (Forbes) to 22 fathoms (Birmingham Natural History Society). The Raasay Sound specimens were obtained ("Depths of the Sea," p. 149) in about 140 fathoms water, and the single specimen from Station 54, of the "Porcupine" cruise, at a depth of 363 fathoms ; the greatest recorded depth. The first Swedish specimen was obtained in 100 fathoms water, and the large dead stem from Glaesvae in 350 fathoms.

Notes on Specimens in Other Museums.

We conclude our account of *Funiculina quadrangularis* by a brief notice of some of the larger and more important specimens preserved in other museums. Though the genus has now been known for considerably more than a century, yet the actual number of specimens preserved in museums is very small. In drawing up the following list our statements concerning the Continental specimens are taken from Kölliker's monograph.

A.—*Great Britain :*

1. London : British Museum. The specimens in the British Museum are the following :—

a. Seven specimens in spirit, labelled *Funiculina Forbesii*, Scotland, varying in length from 18ins. to 37ins.

b. One specimen dried and mounted on a card, 41ins. long, from Sweden.

c. Two very fine specimens from Sweden, received in exchange from the museum at Stockholm, 46ins. long. These specimens agree in their proportions very closely with the large Oban specimen, differing only in their greater size, and the consequent greater number and closer crowding of the polypes.

Other specimens in the British Museum labelled *Funiculina* do not really belong to that genus, as defined by Kölliker.

2. Edinburgh. In the Natural History Museum there are no specimens of *Funiculina* ; but among the stores of the "Porcupine"[†] are eighteen specimens obtained by Sir W. Thomson, and varying in length from 8ins. to 32ins.

3. Glasgow. In the University Museum there is one specimen of *Funiculina* in fragments ; no locality marked.

4. Newcastle-on-Tyne. In the Museum of the Natural History Society of Northumberland, Durham, and Newcastle-on-Tyne, there are two specimens of *Funiculina*, 53 and 42ins. long respectively, which were obtained by Joshua Alder from Loch Torridon in Ross-shire, a locality not far from Raasay Sound, where Sir W. Thomson obtained his specimens. The 53ins. specimen, which is equal in length to the largest living specimen recorded from any locality, is divided into three portions, and the smaller one is doubled in the middle, presumably for convenience of preserving in spirit.

With the exception of the Birmingham specimens the above are, we believe, all the examples of the genus in this country.

B.—*Continent :*

1. Paris : Jardin des Plantes. A specimen, 52ins. long, from the Kattegat.

2. Copenhagen. A very fine specimen, 53ins. long, from the Kattegat.

3. Hamburg : Johanneum. Dead stem, 89ins. long, obtained by Herr Schilling in 350 fathoms of water, near Glæsvae, in the Bergen Fiord. By far the largest specimen yet discovered.

4. Würzburg. A number of specimens collected by Kölliker while preparing his monograph. The largest of these, 50ins. long, is from the Adriatic.

We desire to acknowledge the courtesy of Dr. Gunther, and of Mr. Ridley, of the British Museum, in giving us free access to all the specimens in the Museum, and in affording us valuable aid in examining them.

[†] We are indebted to Prof. Herdman, of University College, Liverpool, for the details we give concerning these specimens.

The following table shows the actual dimensions, in inches, of the large Oban specimen, and of the largest specimens recorded from other localities, together with the museums in which they are preserved :—

	Hamburg Johanneum : Dead Stem from Bergen Fiord.	Newcastle Museum: from Loch Torridon, West Coast of Scotland.	Copenhagen Museum : from Kattegat.	Paris, Jardin des Plantes : from Kattegat.	Wurzburg Museum : from Adriatic.	Wurzburg Museum : from Naples.	Mason College, Birmingham : from Oban.
	in.	in.	in.	in.	in.	in.	in.
Total length	89	53	53	52	50	50	39
,, ,, Feather ..	..	46	46	44½	41	43½	33
,, ,, Stalk ..	..	7	7	7½	9	6½	6
Width of Rachis, widest..	..	..	0·30	0·34	0·48	0·28	0·22
,, Stalk, ,, ..	..	..	0·28	..	0·32	0·22	0·20
,, Stem in Feather	..	..	0·08	..	0·08	..	0·06
,, ,, Stalk..	..	..	0·13	..	0·14	..	0·10
Length of Polype (largest)	..	..	0·30	0·22	0·38	0·26	0·30
,, Zooid (largest)	..	..	..	..	0·07	..	0·05

NOTE.—Since writing the above we have obtained by dredging, at Oban, a number of specimens of *Funiculina*, including a remarkably fine one 65ins. long. This specimen, which is the largest obtained in a living condition from any locality, when brought up had mud still adhering to its stalk, thus affording direct evidence that the natural position is the erect one we have advocated above. All the specimens, when fresh, were of the delicate pink colour noticed by Sir Wyville Thomson.

PART II.

PENNATULA PHOSPHOREA.

LINNÆUS.

Of this species two living specimens were obtained, of 5½ and 4¾ inches' length respectively. They were both found in the same locality (Station I. of the General Report of the Dredging Excursion), two miles N.W. of Oban, and about a mile from the shore, in twenty fathoms water, one being brought up by the tangle and the other inside the dredge-net. A third, smaller, specimen obtained from the same locality was not preserved.

The two specimens prove on examination to be of different sexes, a rare piece of good fortune, which has enabled us to make our report far more complete than could otherwise have been the case, and also to give an account of the structure and development of the male reproductive organs of *Pennatula*, of which no satisfactory description has hitherto appeared.

In order to investigate the anatomical structure a pair of leaves with the corresponding part of the rachis were removed from the male specimen, the less perfect of the two, and of these sections were made in various planes. The knowledge obtained in this way, which was still deficient in many important points, we have supplemented by an examination of specimens of *Pennatula phosphorea* in the Owens College museum, originally obtained from Naples, and in this way have been enabled to prepare a fairly complete account of the anatomy of *Pennatula*. Concerning the histology we have been less successful owing to the imperfect preservation of the specimens.

As in the case of *Funiculina*, we have given special attention to the figures on Plate III., all of which have either been drawn directly from the objects themselves, or else constructed from camera drawings of the several parts shown.

GENERAL ACCOUNT.

The general appearance of *Pennatula phosphorea* is shown in Figs. 1 and 2, the former figure representing the dorsal and the latter the opposite or ventral surface, both figures being drawn from the female specimen.

As in *Funiculina* there is a cylindrical axial portion, of which the lower 2-5ths, forming the stalk (Figs. 1 and 2 *b*), are bare and in the living animal probably planted in the sea-bottom, while the upper 3-5ths, or rachis (Fig. 2 *a*), support the polypes.

These polypes are arranged in transverse rows along each side of the rachis, the several polypes of each row being fused together along nearly their whole length, so as to form broad horizontal *leaves* (Figs. 1, 2, and 3 *ll*), projecting out at right angles to the rachis. The presence of these leaves forms the most marked point of difference between *Pennatula* and *Funiculina*, in which latter each polype is quite free from its neighbours and inserted independently into the rachis.

As in *Funiculina* the polypes are placed along the dorsal and lateral surfaces of the rachis, but not on the ventral surface (Figs. 2 and 3), which, however, unlike *Funiculina*, is thickly studded with zooids (Figs. 2 and 3, *e*).

As shown in Figs. 1 and 2 the leaves are not all of equal length; the longest ones, in the female specimen, are at about one-third of the length of the rachis above its commencement, from which point they diminish gradually in length towards the upper end of the rachis, and much more rapidly towards the lower end. The number of polypes composing the leaves varies according to the length of the leaf; the greatest number, found in the longest leaves, being twelve in the female specimen (Fig. 3 *d*), and in the male fifteen; while the topmost leaves consist of three or even only two polypes each.

The rachis and leaves are of a deep red colour, due, not to the fleshy body-substance which is nearly colourless, but to red calcareous spicules which are present in immense numbers throughout these portions of the Pen (Figs. 3, 4, and 5 *i*). The stalk is much paler, the spicules in it being colourless.

Anatomical Description.

1.—*The Stalk and Rachis.*—

The stalk (Figs. 1, 2, 3) which forms about 2-5ths of the entire length of the Pen, is cylindrical, with a diameter in the female specimen of 0·21in. along the greater part of its length. The bottom third is somewhat dilated and bulbous, and the upper end, just at the junction of stalk and rachis, slightly constricted, forming as in *Funiculina* the narrowest portion of the stalk.

As the Oban specimens were destined for museum purposes we have been unable to investigate the structure of the stalk in them, and the following account is based on a series of preparations made from a couple of specimens in the Owens College Museum, obtained from Naples.

The stalk is really a tube, being traversed along its whole length by an axial canal, whose diameter along the greater part of the length is about half that of the stalk itself, somewhat exceeding this in the upper and lower thirds, and being rather smaller in the middle third. At the bottom of the stalk this canal is said by Kölliker to open to the exterior by a minute orifice, the existence of which we have, however, been unable to confirm.

The central canal is divided into two along the whole length of the stalk by a longitudinal partition; and in the upper half of the stalk, owing to the presence of two other partitions, into four, whereof one is dorsal, one ventral, and two lateral.

The walls of the stalk present the following structure:—On the outer surface is an epidermis, which, although of some thickness, consists of only a single layer of closely-packed columnar cells. Beneath this is a thick connective-tissue layer, or dermis, forming from $\frac{1}{3}$ to $\frac{1}{2}$ the total thickness of the wall. Imbedded in this dermis are an immense number of calcareous spicules crossing one another at every conceivable angle, and set so closely together that in many places the connective tissue matrix is completely concealed by them. These spicules which, unlike the spicules of the rachis and leaves, are colourless, have an average length of 0·013in., and width of 0·001in., the total thickness of the dermis, to which they give considerable strength and toughness, being about 0·016in.

Beneath the dermis is a well-developed system of longitudinal muscles, arranged so as to form not a simple ring round the stalk, but an extremely sinuous or corrugated one, the loops being very deep and close together, and the total thickness of the layer about $\frac{1}{4}$ that of the entire wall. Within the layer of longitudinal muscles is a connective tissue layer of varying thickness in different parts, and traversed by ill-defined bands of muscular fibre whose general direction is parallel to the surface of the stalk, though not forming a distinct system of circular muscles. This layer forms also the basis of the septa or partitions dividing the central canal. Finally, the central canals are lined by a single layer of short columnar epithelial cells.

The walls of the stalk are farther traversed by an irregular system of canals or vessels of no great size, the largest of which have a longitudinal direction and are situated in the loops formed by the layer of longitudinal muscles.

The lower third of the stalk differs materially in appearance from the upper two-thirds: its walls are softer and paler in colour, and owing to the action of the spirit in which the specimens have been preserved, are very distinctly wrinkled. This difference is due partly to the wall of the lower third being somewhat thinner than that of the upper part, but far more to the fact that in this portion the dermis, which, owing to its calcareous spicules, is the most rigid layer o the stalk, is barely half the thickness that it has above.

We have described the stalk as seen in our spirit-preserved specimens, but before leaving it a point of some interest remains to be noticed. The stalk of *Pennatula phosphorea* is described and figured by some writers as of very much greater thickness than we have stated above, and is said to become inflated under certain circumstances or at certain times of the day. Thus Sir John Dalyell*

* Dalyell: "Rare and Remarkable Animals of Scotland," Vol. ii., 1848, pp. 191-194, and Plate XLIV.

says that the whole Pen may distend itself with water, the distension being most marked in the stalk. He remarks that "no one could anticipate the effect of intumescence from its form in a contracted state." Also, that "it enlarges remarkably as evening comes on," *Pennatula* being, according to him, "strictly nocturnal," and, at any rate in captivity, only expanding fully in the evening or at night.

Johnston* also notices that "when placed in a basin or plate of sea-water, *Pennatulæ* . . . . inflate the body until it becomes to a considerable degree transparent, and only streaked with interrupted lines of red."

On the other hand, Panceri†, who has made careful observations on living *Pennatulæ*, holds that this state of distension is not a natural one. He says, "When these zoophytes, living at a depth of 40 or 100 metres (22 to 51 fathoms), or more, are suddenly removed from their natural resting place at the bottom of the sea, and transferred to an aquarium, they undergo so great a change in the pressure, temperature, degree of saltness of the water, and conditions of existence generally, that they swell up gradually to an enormous extent—up to double their natural size." He brings forward as further evidence that this dropsical condition is an unnatural one, the fact that *Pennatulæ* in this state respond exceedingly feebly to stimuli, whether mechanical, chemical, thermal, or electrical, to which, in their natural undistended condition they answer readily.

The above quotations suggest two points for consideration :—(1.) Is this inflation of the stalk of *Pennatula* a constantly occurring or only an exceptional phenomenon? (2.) If constant, is it to be regarded as a normal or as an abnormal occurrence, due, as Panceri suggests, to the exceptional conditions under which the Pen is placed?

Concerning the first point, the united testimony of Dalyell, Johnston, and Panceri proves that at any rate this inflation is no rare event under the conditions named: and through a valuable observation of Mr. J. F. Goode, who kept the log of the Oban excursion, we are enabled to give some account of the process of inflation as it actually occurred in one of the Oban specimens. We learn from Mr. Goode's MS. notes and from a drawing made by him at the time, that when one of the *Pennatulæ*—the male specimen—was placed, immediately after its capture, in a shallow pan of sea-water, the stalk was at first cylindrical with a slightly bulbous extremity (very similar to Figs. 1 and 2); but that shortly afterwards "it was seen to undergo a gradual change of form. A slight constriction took place near the extreme end, driving the fluid contents forward towards the upper part (near the rachis), which became much swollen, leaving only a small bulb at the opposite end. . . . . This form was not at all permanent,

* Johnston: "British Zoophytes," Second Edition, 1847, Vol. ii., pp. 160-161; also, Figure 35, p. 158, where *Pennatula phosphorea* is figured with the stalk thus inflated.

† Panceri: "Etudes sur la Phosphorescence des Animaux Marins," Annales des Sciences Naturelles, Cinquième Série, tome 16, 1872, p. 15.

continued change still going on, evidently with the object of regaining its original form, the fluid seeming to oscillate from one end to the other. The above changes took place in the first twenty minutes from the time of capture."

With regard to the second point, which can, of course, only be settled by direct observations on living specimens, we will only remark here that Mr. Goode's observation that at the moment of capture the proportions of the stalk were those we have described and figured from spirit specimens, is important testimony in favour of these proportions being the normal ones; and further, that Panceri's suggestion appears to us to be of much weight, and that it is quite possible that it also gives the clue to Sir John Dalyell's statement concerning the "nocturnal habits" of *Pennatulæ*. The bottom of the sea at twenty to forty fathoms depth must be very dark indeed as compared with the surface, and it seems to us very probable that a *Pennatula* "in a basin or plate of sea-water" does not expand its polypes fully until the evening, simply because it is only then that the amount of light approximates to what it is accustomed to receive in the day time at the bottom of the sea.

The *rachis* (Fig 2 *a*), or axial portion of the feather or polype-bearing part of the Pen, is widest about the junction of its middle and lower thirds. From this point, at which in the female specimen it has a width of 0·29in., it tapers gradually in both directions. Its dorsal surface (Fig. 1) is completely concealed by the polypes, and of the lateral surfaces only small portions are visible between the bases of the leaves. The ventral surface is, however, exposed along its whole length (Figs. 2 and 3); it is marked by a shallow median longitudinal groove, more pronounced in the female than the male specimen, and is studded all over with the zooids or rudimentary polypes. In colour it contrasts strongly with the stalk, being of a bright red colour, excepting the median groove which is pale yellow.

The internal structure of the rachis is shown in Fig 3. The central canal, which is of very large size, is divided by the septa shown in this figure into four; a very large dorsal one, two large lateral ones, and a small ventral one crescentic in transverse section. In the great size of these canals, which do not appear to have been figured hitherto, *Pennatula phosphorea* contrasts remarkably with the allied species *Pennatula rubra*, as described and figured by Kölliker,* in which the dorsal canal is very small, and far removed from the others, which are themselves much smaller than in *P. phosphorea*.

The structure of the wall on the mid-dorsal and on the ventral surfaces is, but for the presence of the zooids, much the same as that of the stalk. A single-layered epidermis covers a thick dermis exceedingly closely studded with calcareous spicules, packed together if possible even more closely than in the stalk; beneath the dermis is

* Kölliker: Anatomische-systematische Beschreibung der Alcyonarien. Erste Abtheilung; Die Pennatuliden. 1872, Plate VIII., fig. 72.

a well-developed layer of longitudinal muscles, having the same arrangement as in the stalk; and underneath this a connective-tissue layer which differs considerably from that of the stalk, for instead of forming a dense compact layer it has the character of a loose spongy meshwork, traversed by large irregular canals and passages freely opening into one another and into the canal system between the folds of the longitudinal muscles.

At the sides the structure of the wall between the several polype-leaves is much the same as that just described on the dorsal and ventral surfaces, with the exception that the longitudinal muscle layer is absent, and the spongy connective-tissue layer consequently thicker; but opposite the bases of attachment of the leaves it is very different. As shown on the left-hand side of Fig. 3, the wall is here reduced to a thin connective-tissue membrane, separating the bottoms of the polype cavities from the main dorsal and lateral canals.

The partitions separating the main canals from one another are, as in the stalk, formed by prolongations of the connective-tissue layer; the canals themselves being lined by a single layer of epithelial cells. In the septum dividing the two lateral canals from one another is contained, as will be described more fully below, the calcareous axial rod or stem (Fig. 3, *c*).

The function of the whole canal system of *Pennatulida* is a matter of much uncertainty. The meshes of the spongy connective-tissue communicate freely with the cavities of both polypes and zooids, and also, according to Kölliker, with the main canal system of the rachis and stalk. The fluid in this system is probably a nutritive one, mixed however very largely with sea-water; and the well-developed muscular system may be supposed to have for its main function the maintaining, by compression of portions of the spongy connective-tissue meshwork, of currents from one part of the Pen to another, and in part to effect the slight movements of the leaves described by many writers, notably by Dalyell, who says that "the animal has also much control over the dimensions, reciprocal position, and direction of the lobes,"* *i.e.*, leaves.

2.—*The Stem.*—

As in *Funiculina*, the stalk and rachis are traversed by a central firmly-calcified stem (Fig. 8), situated, as shown in Fig. 3 *c*, in the middle of the septum dividing the two main lateral canals from one another. We have investigated the structure and anatomical relations of the stem in two of the specimens of *Pennatula* from Naples referred to above.

The first of these specimens has a total length of 4½in., whereof the stalk forms the lower 1⅗in., and the rachis the remainder. The rachis bears twenty-seven leaves on each side, each of the larger ones being composed of eleven polypes. The stem (Fig. 8 *c*) is thickest at the point of junction of stalk and rachis, at which place it has a diameter

* Dalyell, *op. cit.*, p. 192.

of 0·044in. A point of considerable interest is that at this spot the stem is very distinctly quadrangular in transverse section, the sides being even slightly concave as in *Funiculina*. This quadrangular shape of the stem of *Pennatula* appears to have been hitherto very generally overlooked. From the point mentioned the stem extends down to the bottom of the stalk, preserving its quadrangular character until very close to the bottom where it becomes cylindrical. Its diameter diminishes at first very gradually, but in the bottom half-inch very rapidly. On reaching the bottom of the stalk it is bent back on itself, so as to form a hook, the loop of the hook being in contact with the bottom of the stalk, and the upturned limb of the hook, which is $\frac{1}{4}$in long, being extremely slender and only very imperfectly calcified. The extreme tip is bent back a second time towards the lower end of the stalk for a length of about $\frac{1}{8}$in.

In the rachis the stem loses its quadrangular character almost immediately, becoming cylindrical ; its transverse section being circular or somewhat oval (Fig. 3 *c*). It tapers gradually in passing upwards, and on reaching a point $\frac{3}{4}$in. from the top of the rachis bends back on itself for a length of about $\frac{1}{2}$in., ending in an extremely slender and flexible thread.

In the second specimen, which has a total length of $5\frac{1}{2}$ins., of which the stalk forms the lower 2ins., and which has thirty-one leaves on each side of the rachis, each of the larger ones consisting of twelve polypes, the general relations are very similar. The stem is again distinctly quadrangular at the junction of stalk and rachis, its sides being even more decidedly concave than in the former specimen ; and the quadrangular character is preserved until very near the bottom of the stalk. As before, the stem diminishes in diameter very slowly at first, but rapidly in the last half inch. It extends to the bottom of the stalk, and then turns back on itself for a length of $\frac{1}{8}$in., forming a hook and ending in a very slender thread.

In the rachis the stem becomes cylindrical almost at once, and, unlike the former specimen, slightly increases at first in size, its greatest diameter, 0·047in., being attained about $\frac{1}{2}$in. above the commencement of the rachis; from which point it tapers gradually to its upper end. It extends up as far as the level of the eighth pair of leaves, $\frac{3}{8}$in. from the top, and then bends back on itself, forming a loop about $\frac{1}{4}$in. long, and ending as before in an exceedingly slender thread.

In the Oban specimens we have been able to confirm the above description to a certain extent. Owing to the thinness of the wall of the lower end of the stalk, it is easy to demonstrate that the stem extends quite down to the bottom and then turns back on itself for a certain distance ; also, that it is thin and flexible at this lower end. In the rachis it is, as shown in Fig. 3 *c*, oval in transverse section ; and concerning its extent upwards, it appears, so far as can be determined by external manipulation, to stop about half an inch from the top.

The stem consists of a dense fibrous matrix, in which the fibres are mainly concentric, but partly radial, impregnated with calcareous salts. Unlike *Funiculina*, the central part of the stem is as firmly calcified as the exterior.

The quadrangular character of the stem in the stalk is of interest, as it has hitherto been very generally considered diagnostic of *Funiculina*, which however, unlike *Pennatula*, preserves the quadrangular form in the rachis as well.

Concerning the proportions of the stem at different parts of its length, the remarks that we have already made when considering *Funiculina** apply also to *Pennatula*, the proportions being precisely those which, mechanically considered, adapt it most perfectly to the erect posture with the stalk planted in the mud of the sea bottom. We shall return to this point subsequently.

3.—*The Polypes and Zooids.*—

The differences between the two kinds of individual animals, polypes and zooids, composing the colony, are far more marked in *Pennatula* than in *Funiculina*, owing mainly to the fact that instead of both polypes and zooids being inserted separately into the rachis, the polypes are fused together to form the leaves, while the zooids, as in *Funiculina*, are planted independently of one another.

The structure of one of these leaves is shown in Fig. 3. Each leaf is triangular in shape, having a short base by which it is attached to the side of the rachis, and long dorsal and ventral borders. The leaf consists of a number of polypes placed side by side and fused together along nearly the whole of their length, the oral ends alone being free. It is important to realise this fully, and to avoid the very common error of speaking of the polypes as "borne on or by the leaves;" the leaves simply consist of the polypes, each one of which is directly attached to the rachis.

The free oral ends of the polypes are situated along the dorsal border of the leaf; and each polype, as is clearly shown in Fig. 3, extends down to the rachis and is separately inserted into it. The consequence of this is that the several polypes composing a leaf are of very different lengths, the ones whose mouths are nearest the median plane of the whole *Pennatula* being very short, while those whose mouths are at or near the apex of the leaf are of much greater length.

It will further be seen from Fig. 3 that while the base of the triangular leaf is formed by the lower ends or bases of the several polypes, and the dorsal border by their free oral ends, the ventral border is formed exclusively by the most ventrally situated of the component polypes, which is also the longest of the whole set. The dorsal and ventral borders of the leaf are not quite straight but curved as shown in the figure.

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* *Supra*, p. 5.

The number of leaves in the male specimen is thirty-six on either side, and in the female thirty-four. The leaves are not arranged strictly in pairs on the opposite sides of the rachis; at certain parts they may be so paired, while in others they alternate regularly. The successive leaves are, as shown in Figs. 1 and 2, placed very close together, their bases being separated by only a thin strip of the side of the rachis less than half the thickness of a leaf.

As already noticed, and as shown in Figs. 1 and 2, the leaves are not all of the same size; the largest, which have a length of $\frac{7}{8}$in. in the female specimen, being situated in it a little below the middle of the rachis, but in the male specimen a little above this point. This difference in the position of the largest leaves causes a characteristic difference in the general shape and appearance of the two specimens; a difference which may possibly prove to be an external sexual distinction, though we have as yet no further evidence in support of this suggestion.

The number of component polypes varies, as already noticed, with the length of the leaf; the maximum number, fifteen in the male and twelve in the female specimen, being only found in the leaves about the middle of the series.

The base of each leaf extends very nearly, but not quite, to the mid-dorsal line of the rachis (Fig. 3). The most dorsally situated polype of each leaf, which we have seen is also the shortest, usually projects over towards the opposite side beyond the middle line (Fig. 3), and these dorsal zooids projecting across the middle line alternately from either side give rise to the zigzag appearance seen down the mid-dorsal line in Fig. 1.

Concerning the mode of development of the leaves we have noticed the following points:—The most dorsally situated polype of a leaf is very often decidedly smaller than the other polypes, and this is especially the case in small and apparently young specimens. Towards both top and bottom of the rachis the leaves are smaller, and consist of fewer polypes than in the middle portion; but between the top and bottom leaves there is this difference,—in the top leaves all the polypes are large, fully formed, and of equal size; but in the leaves at the bottom of the rachis all the polypes are below the average size, the dorsal ones are the smallest of all and may be rudimentary, while the more ventrally situated ones gradually increase in size and the largest of all is the most ventral one.

From these facts we conclude (1) that in the development of each leaf the ventral polypes are formed first, and the others in succession one above the other, so that the ventral polype of a leaf is not only always the longest but also always the oldest, while the most dorsally situated one is both the shortest and the youngest. Each polype is thus at the time of its first appearance the most dorsal one of the leaf to which it belongs, and becomes subsequently pushed down towards the ventral surface by the formation of younger ones still more dorsally situated, space being provided for these new ones by the lateral growth of the rachis itself. This view also explains the fact, noticed above, that the most dorsal polype of each leaf projects across the middle line over to the opposite side, this being the only direction in which its growth is not opposed by neighbouring polypes. (2) That the uppermost leaves are the first-formed ones, and therefore the oldest, and that new leaves are formed at the bottom of the rachis below the previously-formed ones, the lowest leaf being always the youngest.

These conclusions agree completely with what we have stated already concerning *Funiculina*, in which, as in *Pennatula*, development of the polypes appears to proceed from the dorsal towards the ventral surface, and from below upwards, the ventral polypes being always the largest and oldest, and the dorsal ones the smallest and youngest.

The zooids, or rudimentary asexual individuals, cover as already noticed the whole ventral surface of the rachis excepting the median groove, which is often barely perceptible in the upper half of the Pen. They also extend up the sides of the rachis between the bases of the leaves (Fig. 3 *e*), and form on the dorsal surface little clusters between each pair of leaves. The zooids exactly reverse the arrangement we have found to hold among the polypes, the ventral zooids being the smallest and the dorsal clusters invariably the largest. In the case of the younger leaves these dorsal zooids are not much smaller than the youngest or most dorsal polypes, and it is possible that they may develope into them, as we have supposed to occur in *Funiculina*. We have not, however, had sufficient material at our disposal to enable us to determine this point.

4.—*Anatomy of the Polypes.*—

The polypes of *Pennatula* agree in all essential features with those of *Funiculina* already described,* the differences, which are of merely secondary importance, being due mainly to the fusion of the polypes to form leaves in *Pennatula*.

The structure of the polypes is shown in Figs. 3, 4, and 5; Fig. 3 representing a whole leaf, with its component polypes; Fig. 4, a longitudinal section through one polype taken along the line AA in Fig. 3 vertically to the surface of the leaf; whilst Fig. 5 represents a transverse section of the leaf along the line BB in Fig. 3, the section cutting the six most ventrally-situated polypes of the leaf at different points of their length.

We propose now to consider the several parts of the polype, taking them in the same order as in the description of *Funiculina*.

a. *The Body-wall* consists, as in *Funiculina*, of a firm gelatinous mesoderm (Fig. 5 *x*), clothed on its outer and inner surfaces by ectoderm (*w*) and endoderm (*y*) respectively. The mesoderm, and therefore the body-wall of which it forms the greater part of the

* *Supra*, pp. 25—36

substance, is thinner than in *Funiculina*, from which it differs further in being very closely beset with the characteristic red calcareous spicules (Figs. 3, 4, 5 *i*). These spicules are of very various sizes and placed in different directions, though usually with their long axes more or less parallel to that of the polypes; their shape and other characters will be described farther on.

The partition walls between the several polypes of a leaf have the same structure as the external body-wall, but are very much thinner, the mesoderm being hardly thicker than the cellular endoderm clothing it: they are also devoid of spicules (Fig. 5). These partitions are, so far as we have been able to determine, imperforate, so that the body cavities of the several polypes are completely separated from one another, and in this respect our observations accord with those of Kölliker on *Pennatula*, though in the allied genus *Pteroeides* he has shown that wide apertures exist in the septa, thus placing the polypes in direct communication with one another.

The bottom of the polype cavity is separated from the dorsal or lateral canal of the rachis by a very thin wall (Figs. 3 and 4), and the cavities of the ventral polypes appear to communicate with the meshes of the spongy connective-tissue of the rachis-wall.

The free oral ends of the polypes have thicker walls than the parts which are fused to form the leaf; and these free ends are strengthened by numerous very large and stout spicules, whose direction is mainly longitudinal.

The longitudinal muscles of the rachis are not prolonged into the leaves, the muscular system of which is extremely feebly developed.

b. *The Calyx*.—As in *Funiculina*, the calyx (Figs. 3 and 4 *g h*) is produced into eight hollow processes, alternating with the tentacles. These processes are longer and more pointed than in *Funiculina*, and are stiffened by very numerous spicules, many of which are of very large size; indeed the spicules are both more abundant and of greater size in the calyx than in any other part of the polype. In most of the polypes the ends of the spicules project freely beyond the ends of the processes for a short distance; but this condition is almost certainly to be ascribed to the action of the spirit in which the specimens are preserved having caused the fleshy body substance to contract and so leave the ends of the spicules bare.

When the polypes are retracted, the calyx processes are by the action of the retractor muscles (Fig. 6 *p*) pulled in towards one another, and meeting in the middle form a pointed conical cover completely protecting the entrance to the polype cavity (Fig. 3).

The calcareous spicules, which form so characteristic an element in the structure of *Pennatula*, may be described here. They occur in great numbers along the whole length of both upper and under surfaces of the leaves, being more closely placed along the lines of division between the component polypes (Fig. 5) than at the intervening portions. In the free oral ends of the polypes, and especially in the calices, they are far more numerous than in other parts of the polypes, being set so close together as to be almost in contact with one another; they are also, as we have seen, exceedingly abundant in the dermis of both stalk and rachis.

The spicules, which are always mesodermal structures, vary much in size in different places. They are straight rods, about twenty times as long as they are wide: in the polypes the smallest spicules have a length of about 0·005in., while the largest ones measure 0·046in. long by 0·002in. wide, the average length being about 0·015in. The transverse section varies in shape according to the size of the spicules; the smaller spicules are, as shown in Fig. 6, very distinctly triradiate, but of a heavier and less elegant pattern than in *Funiculina* (*cf.* Plate I., Fig. 9). In the larger spicules the grooves between the ribs are filled up more or less completely, as shown in Fig. 7, while the largest spicules of all have entirely lost the triradiate character and are circular in section. This relation between the size of the spicules and their shape in tranverse section appears to be a very constant one, so that for each length of spicule there is a characteristic shape in section, which is rarely departed from to any considerable extent.

The spicules are not unfrequently rather wider in the middle than towards the ends, which latter are slightly rounded off. As already stated, the spicules are bright red, the red colour of the leaves and rachis being due entirely to them.

c. The *Tentacles*, as in *Funiculina*, are eight hollow processes of the body-wall placed round the mouth, and bearing on each side a row of from ten to fifteen hollow pinnules (Fig. 6, *f*). The tentacles are shown in transverse section near to their bases in the uppermost section of Fig. 5, which shows their structure at this part. Each consists of an outer layer or ectoderm, with abundant thread-cells or nematocysts; an endoderm lining the central canal, and continuous with the endoderm of the body-cavity; and a mesoderm, which at the sides and inner surface of the tentacle is thin, as in *Funiculina*, and consists of a layer of longitudinal muscles with an inner much weaker layer of circular muscle-fibres. At the outer side of the tentacle the mesoderm (Fig. 5) is very much thicker, and resembles in structure the mesoderm of the body-wall, consisting, in addition to an outer layer of longitudinal muscles, of a gelatinous connective-tissue matrix in which are embedded a number of calcareous spicules (Fig. 5, *i*).

The pinnules are at the lower end of the tentacle rather long, thin, and some distance apart; towards the upper end they become thicker and more closely set together. Their cavities open into the central cavity of the tentacle, and their structure is the same as that of the tentacle itself: they may even contain small calcareous spicules.

d. *The Stomach*, as seen in Figs. 4 and 5, is very similar to that of *Funiculina*. It is short, and is entirely contained in the free portion of the polype: its walls are thrown into transverse folds, which, when the polype is retracted, are approximated like the folds of a concertina so as to reduce the stomach to less than half its normal length.

The walls of the stomach agree in structure with those of *Funiculina*, consisting of a thin glandular lining membrane or ectoderm which is distinctly ciliated, a thin connective-tissue mesodermal layer, and a moderately thick outer or endodermal layer, containing numerous spherical highly refractive granules similar to those described in *Funiculina*.

e. The Mesenteries (Figs. 4 and 5 *o*), eight in number, connect the stomach with the body wall, and extend below the stomach the whole length of the polype, as far down as the rachis. They may be divided into a set of two, situated on the upper surface of the leaves, and bearing below the stomach the long mesenterial filaments *s*; and a set of six which bear the short mesenterial filaments *r*, and of which two are attached to the under surface of the leaf, two to the dorsal wall of the polype, and two to the ventral wall.

Around the stomach the eight mesenteries are arranged at nearly equal intervals, as shown in the second section of Fig. 5; but even here it will be noticed that the mesenteries are rather closer together toward the right-hand side of the figure, corresponding to the lower surface of the leaf, than they are on the left-hand side of the figure, or upper surface of the leaf.

Below the stomach this asymmetry becomes still more marked, the set of six mesenteries becoming crowded together towards the under side of the leaf, while the two upper mesenteries, bearing the long mesenterial filaments *s*, move slightly away from one another, and become situated as shown in the lower section of Fig. 5 close to the partitions dividing the polype from its neighbours on either side.

Still nearer the rachis, *i.e.*, below the lower ends of the short mesenterial filaments, the six mesenteries become more irregularly arranged; they now form (*vide* Fig. 4 *o* and the three lower sections in Fig. 5 *o*) very small longitudinal ridges, only projecting a very short way into the cavity of the polype; as a rule, three of the six are situated on the under surface of the leaf, owing to one of the lateral ones shifting its attachment from the side to the under surface. This arrangement, which is acquired shortly below the lower ends of the short mesenterial filaments (Fig. 4 *r*), persists down to the bottom of the polype-cavity.

The structure of the mesenteries and the arrangement of their muscular system is the same as in *Funiculina*. The retractor muscles of the polype (Figs. 4 and 5 *p*) arise from the body wall and run up in the mesenteries to be inserted into the mesodermal layer of the stomach; while the protractor muscles (Fig. 4 *q*) which are much feebler, arise from the upper part of the sides of the body, and running downwards and inwards in the mesenteries, are inserted like the retractors into the stomach wall.

As shown in the second section of Fig. 5, the protractor muscles are situated on one face only of the mesenteries, and a comparison of this figure with Fig. 13 of Plate II. will show that the actual arrangement is the same as in *Funiculina*. The two upper mesenteries, which bear below the stomach the long mesenterial filaments, and are situated on the left-hand side of both the figures referred to, have the retractor muscles on the sides facing away from one another; the two opposite mesenteries, those on the lower surface of the leaf and the right-hand side of the figures, have the retractor muscles on the sides facing one another, while the intermediate or dorsal and ventral mesenteries bear the muscles on their right-hand sides in the figures.

It is clear therefore that, as in *Funiculina*, there is only one bisecting plane that will divide the polype into two perfectly symmetrical halves, and it is also evident from Figs. 3 and 5, and from the description given above that the *plane of symmetry* is perpendicular to the flat surface of the leaf, and is therefore the plane of section adopted in Fig. 4.

The retractor muscles pull back the bases of the tentacles, and at the same time shorten the stomach, as described above, so as to make room for them: the completion of the retraction of the tentacles is effected by their own intrinsic system of longitudinal muscles; and the final action of the great retractor muscles is by pulling on the bases of the calyx processes to bring these towards one another and so completely close the mouth of the polype cup.

f. The Mesenterial Filaments.—The mesenterial filaments, which are simply the thickened edges of the mesenteries below the stomach, fall as already noticed into two groups; a set of two situated on the upper surface of the leaf and extending down to the bottom of the polype cavities, the *long mesenterial filaments* (Figs. 4 and 5 *s*); and a set of six, the *short mesenterial filaments*, Figs. 4 and 5 *r*, which only extend a short way below the stomach.

The long mesenterial filaments have the same character along the whole of their length: they are straight, or very slightly convoluted, and are in transverse section (Fig. 5 *s*) bifid, the filament and mesentery together having the appearance of a letter Y with very thick arms. Each arm consists of a thin stratum of connective tissue, clothed on its upper surface—that towards the upper surface of the leaf—by a thin layer of flat epithelial cells, and on its under surface by a single layer of elongated columnar ciliated cells, which are granular in appearance, and possibly in part of glandular nature. Concerning the function of these long mesenterial filaments we know nothing.

The short mesenterial filaments, Figs. 4 and 5 *r*, are, like those of *Funiculina*, thick and much convoluted. They are rather shorter than those of *Funiculina*, being not quite so long as the stomach in its expanded condition, and their length is the same in all the polypes of the leaf, however long or short these themselves may be. They commence about the spot where the polypes become free from one another, so that the greater part or the whole of their length is contained in the leaf proper.

The structure of the short mesenterial filaments is, as shown in Figs. 4 and 5, the same as in *Funiculina*, each consisting of a connective tissue lamella clothed on each side by a thick layer of special glandular and ciliated endodermal cells. Concerning the function of these filaments we have been able to make some observations which tend to strongly confirm Dr. Krukenberg's conclusions* that they are really digestive organs.

In a number of the polypes we have observed solid bodies imbedded either partially or completely in the mesenterial filaments; examples of this are shown in the third section in Fig. 5, *f o*. These bodies are clearly of a foreign nature; they are also evidently organised, and appear to be undergoing decomposition. From the observations of Dr. Krukenberg on the digestive properties of these mesenterial filaments in Sea-anemones, there can be no doubt that these foreign bodies are organisms or portions of organisms which have been swallowed as food and are undergoing digestion. In this case it is of great interest to notice the very marked power possessed by the filaments of wrapping themselves around the food particle, so as to attack it, as it were, from all sides at once. The importance of this operation is seen at once from Dr. Krukenberg's account of the act of digestion as being a surface action, only occurring where there is actual contact between the filament and the food particle, and not effected by means of a fluid secretion poured out over the food.

It is also important to notice that the endodermal cells of the mesenterial filaments must in order to effect this enveloping of the food, manifest active changes of form—*i.e.*, must be amœboid, and the fact that those endoderm cells which are specially concerned in digestion are amœboid has now been established in a considerable number of *Cœlenterata*.†

In the case of one of the polypes of which we have prepared sections—the third section from the top in Fig. 5—an additional point of interest has presented itself. Lodged within the polype with its head just at the level of the bottom of the stomach, and its body lying imbedded among the mesenterial filaments, is an Entomostracon, apparently one of those parasitic or semi-parasitic *Copepoda* in which the jaws are retained in a well-developed condition, but the other appendages are rudimentary. The ovaries of this Copepod are in a condition of great activity, containing very numerous ova in various stages of development. Many of the ripe ova have left the parent and are either lying freely in the body-cavity of the polype or else are embedded in the mesenterial filaments in the same manner as are the food particles described above. An instance of this is shown in the

* *Vide supra*, p. 17.

† For a summary of recent observations on the amœboid condition of the endoderm in *Cœlenterata* and other forms, and for important observations on the process of digestion in the fresh-water Medusa *Limnocodium*, vide Lankester "On the Intracellular Digestion of Limnocodium," Quarterly Journal of Microscopic Science, January, 1881.

third section of Fig. 5 at *ov*, which shows also that the egg after becoming completely embedded in the mesenterial filament has commenced to develope, the stage figured being that in which it has divided into four equal segments. Other eggs from the same specimen have proceeded considerably further in their development.

It is difficult in this case to determine whether, on the one hand, the Copepod has been swallowed as food and has escaped digestion so far owing to the thick cuticle covering and protecting its body, the eggs being also destined ultimately to serve as food, and being engulphed by the mesenterial filaments for that purpose, but having, owing to their firm investing membrane, not only escaped digestion, but been enabled to develope up to a certain point; or, on the other hand, whether we are not dealing with a parasitic animal which has planted itself at the bottom of the stomach, so as to intercept the food supplies captured by the polype, and which has found in the mesenterial filaments a suitable nidus for the development of its eggs.

Although the general appearance of the Entomostracon, which we have been unable to identify, suggests parasitic habits, and although there is no sign of either the animal itself or its eggs undergoing digestion, we are disposed, in the absence of any more definite evidence, to adopt the former view, though fully recognising the possibility that the latter one may prove to be correct.

g. The Reproductive Organs. Concerning the reproductive organs of *Pennatula*, we have been able to make some observations of interest, owing to the fact that the two Oban specimens are of opposite sexes.

Lacaze-Duthiers * was apparently the first to show that in *Pennatula* the male and female organs are borne on separate colonies. He examined, however, only a very small number of specimens, and merely records the fact that the sexes are distinct, without giving any description or figures of the reproductive organs.

Kölliker † also, though noticing that the sexes are distinct in *Pennatula*, describes them very briefly, and gives no figures; indeed, no satisfactory account appears to have been published hitherto.

Externally, there appears to be no definite or constant difference between the two sexes; a difference in shape between the two Oban specimens has already been alluded to as a possible distinction, but whether it is so or not could only be decided by an examination of a far larger number of specimens than we have had an opportunity of investigating.

In the female specimen, Figs. 1 and 2, the reproductive organs are closely similar to those of *Funiculina*. The edges of the six mesenteries which bear higher up the short thick filaments act as ovaries, and the ova appear as individual epithelial cells, which grow rapidly, and are from the start invested by a thin

* Lacaze-Duthiers, "Des Sexes chez les Alcyonaires." Comptes Rendus de l'Academie Imperiale de Paris, 1865, tome 60, pp. 840—843.

† Kölliker: *op. cit.*, p. 125.

membranous sheath, and later on by a second outer, very thick and strong capsule, formed by the surrounding epithelial cells. During the greater part of their development the ova are attached by short stalks to the edges of the septa, and project freely into the body-cavity of the polype.

When ripe the ova become detached from the stalks and lie freely in the polype-cavity. Each ripe ovum is a spherical body about 0·015 in. diameter, consisting of a very dense pigmented outer capsule of great strength and considerable thickness, with its surface marked as in *Funiculina* by an irregular network of low ridges, and presenting at one spot a very conspicuous aperture or *micropyle* for admission of the spermatozoa; within this capsule is a second inner and much thinner membrane, inside which is the ovum itself; this consists of granular protoplasm imbedded in which, usually close to one side, is a very large and evident germinal vesicle containing one or more large spherical germinal spots.

Ova occur in all the leaves of the female specimen except the very youngest ones, those at the bottom of the rachis, and as a rule in each component polype of the leaf. They are far more abundant in all stages of development at the lower or basal end of the polypes, where they often form compact masses completely filling up the polype-cavities, than at the upper ends.

The ripe eggs are found in small numbers near the upper part of the polypes, and, as Johnston has pointed out, "by a little pressure can be made to pass through the mouth."* Lacaze-Duthiers holds that fertilisation and the earliest stages of development are effected within the body of the parent, the embryo escaping as a ciliated planula, which, after swimming freely for a time, fixes itself, grows up and developes by repeated budding into a *Pennatula*; and Dalyell's description of the process as observed by himself in *Virgularia* strongly supports this view.†

The male reproductive organs are very similar to the female ones. They develope in exactly the same situation, and in a very similar manner. When adult they are almost identically the same size as the ova, and have very much the same appearance, even under moderately high powers of the microscope. So close is the resemblance, and so completely do the spermatospheres or spherical masses of spermatozoa (Figs. 3, 4, 5, *ts*) counterfeit the ova of the female, that nothing could be easier than to mistake the males for females.

We ourselves fell into this error at first, and for some time were under the impression that our male specimen was, from the apparently obvious eggs that it contained in such large numbers, really a female; and it was only after cutting sections of these supposed eggs, and

* Johnston: "British Zoophytes," vol. i., 2nd Ed., 1847, p. 159.

† Dalyell "Rare and Remarkable Animals of Scotland," 1848 vol. ii. p. 188.

examining them with high powers ($\frac{1}{12}$ in. and $\frac{1}{16}$ in.), that we discovered their real nature.

Like the eggs in the female, the male organs are developed on the edges of the septa, which bear, higher up, the short thick mesenterial filaments. So far as we have been able to determine only four of these six septa bear these organs, namely, the dorsal and ventral pairs of each polype-cavity, the pair belonging to the under surface of the leaf being, as a rule, if not indeed constantly, sterile.

As in the female the reproductive organs are borne by all the leaves except the very youngest, and by all the polypes of each leaf, being far more abundant in all stages of development at the basal ends of the polypes than towards their free extremities.

In the earliest stages of development that we have noticed, the male organs (Figs. 4 and 5, *ts*) are small knobs composed of spherical nucleated cells, surrounded by a capsule of flattened epithelial cells, and attached to the edge of the septum by a short stalk.

In the next stage, the spermatosphere, as we may call it, has increased considerably in size, and the component sperm cells are far more numerous though of smaller size than before. A little later a central space appears in the middle of the spermatosphere, which has now a radiately striated aspect. Soon after this the spermatosphere becomes detached from its stalk and lies free in the polype-cavity.

It is now a spherical body with an average diameter of 0·014 in., and consists of an outer cellular capsule much thinner and less tough than that of the egg; within this is a very thin membranous coat, inside which are an enormous number of minute oval highly refractive bodies, the heads of the spermatozoa, many of which have long filamentary tails attached to them. In the centre of the spermatosphere is a clear space in which no sperm cells or heads of spermatozoa are present, but in which the thread-like tails of the spermatozoa can be clearly distinguished under high powers of the microscope.

Spermatospheres having this structure are found far forward in the polypes close to the mouths through which they undoubtedly escape; but whether the spermatospheres break up on escaping from the polype into their constituent spermatozoa, or remain for a time in the condition described above, we have been unable to determine. We have seen no indication of a tendency to break up in any of the spermatospheres, and yet these have no inherent power of locomotion for the epithelial capsule enclosing them is not ciliated.

In order to satisfy ourselves as to whether the sexes are really distinct, we have examined the reproductive organs from about a dozen different leaves of each of the specimens, selecting leaves from both sides and from very various parts, with the result that all the leaves examined of the one specimen bear male organs and of the other female: from which we feel justified in concluding that Lacaze-Duthiers is correct in stating that the sexes in *Pennatula* are distinct.

We have also investigated for the same purpose and in the same manner four specimens of *Pennatula* in the Owens College Museum, the result being to confirm the above conclusion in all cases.

Our account of the male *Pennatula* will be found to agree very closely with the description given by Kölliker* of the male of *Halisceptrum*, a genus belonging to the same family as *Pennatula* and differing from it mainly in possessing no calcareous spicules in the leaves. Concerning the relative abundance of the two sexes, out of six specimens of *Halisceptrum* examined by Kölliker five were females and only one a male; while of the six specimens of *Pennatula* we have had an opportunity of studying, two are females and four males. The close similarity, if not identity, in external form between the two sexes, and also the close resemblance of the spermatospheres to the ova, must make us very cautious about accepting statements concerning the sexuality of specimens, unless it is explicitly stated that the character of the genital products has been determined by the microscope.

5.—*Anatomy of the Zooids.*—

The zooids of *Pennatula*, like those of *Funiculina*, differ from the polypes in the following structural points, besides the differences in size and position already noticed:—

1. Though there is a well-developed stomach, and as a rule a mouth as well, there are no tentacles or calyx.

2. All eight mesenteries are present around and supporting the stomach, but only two of the eight have their free edges below the stomach thickened to form mesenterial filaments. The two mesenterial filaments present extend down to the bottom of the body cavity of the zooid, and clearly correspond to the two long slender filaments of the polypes.

3. The zooids have no reproductive organs. The walls of the zooids are very thickly studded with calcareous spicules, and the lower ends of the zooid cavities communicate freely with the spongy canal system of the wall of the rachis. At least two thirds of the length of each zooid is embedded in the wall of the rachis, so that it is only by making sections of the rachis that the anatomy of the zooids can be ascertained. The smaller zooids have no mouths, and are therefore dependent for their nutriment on the supply brought by the canal system from the polypes.

6.—*Zoological Position and Affinities.*—

The general position of *Pennatula* in the order *Pennatulida* is shown in the table on page 1 of this report. The generic characters, as given by Kölliker,† are as follows:—

"Genus: *Pennatula*—True Sea-pens, with well developed leaves, in which there are no zooids and no very large calcareous rods ‡ but a

* Kölliker: *op. cit.*, pp. 164-167. † Kölliker: *Op. cit.* p. 122.
‡ As in *Pteroeides*, *e.g.*

number of small spicules. Zooids situated along the whole ventral surface of the rachis, and also on the lateral surfaces between the leaves. Polypes in cups, beset with calcareous spicules; calyx processes variable in number."

Kölliker distinguishes four species of *Pennatula*, whose leading characters are as follow:—

1. *Pennatula phosphorea*. Leaves formed of single rows of polypes, eight to eighteen in number, eight calyx processes to each polype; reproductive organs contained in the leaves.

2. *Pennatula rubra*. Leaves formed of single rows of polypes, twenty-five to forty-six in number, placed alternately, so as to give the appearance of double rows. Calyx processes usually three or four to each polype; reproductive organs confined to the parts of the leaves within the rachis.

3. *Pennatula borealis*. Large pens, up to thirty-two inches long leaves thick, formed of two to four rows of polypes.

4. *Pennatula fimbriata*. Leaves formed of two rows of polypes.

Of *Pennatula phosphorea*, to which the Oban specimens clearly belong, three chief varieties are mentioned by Kölliker:—

a. *P. phosphorea*, var. *angustifolia*. Leaves long and narrow; polype heads few in number, and wide apart.

b. *P. phosphorea*, var. *lancifolia*. Leaves lanceolate; polype heads numerous and placed close together. Of this variety, to which the Oban specimens are to be referred, Kölliker distinguishes four sub-varieties.

c. *P. phosphorea*, var. *aculeata*. Leaves narrow and some distance apart; on ventral side of rachis are four to six rows of prominent spines connected with the zooids.

7.—*Habits*.—

1. *The Natural Position of Pennatula*.—On this point the various zoologists who have described *Pennatula* from living specimens differ remarkably.

Ellis,* speaking of *Pennatula*, says:—"This genus of animals differs remarkably from all the other Zoophytes by their swimming freely about in the sea, and many of them having a muscular motion as they swim along. I know of none of them that fix themselves by their base, notwithstanding what has been wrote." Other anatomists have described *Pennatula* as having the power of swimming freely, and Dr. Grant goes so far as to say that "a more singular and beautiful spectacle could scarcely be conceived than that of a deep purple *P. phosphorea*, with all its delicate transparent polypi expanded and emitting their usual brilliant phosphorescent light, sailing through the still and dark abyss by the regular and synchronous pulsations of the minute fringed arms of the whole polypi."

* Ellis and Solander. Natural History of Zoophytes, 1786, p. 60.

This is doubtless very beautiful, but unfortunately does not appear to have the smallest shred of direct evidence in its support. It is difficult to get to the origin of these accounts, but this is apparently to be found in an observation of Bohadsch, whom we have already mentioned as the first describer of *Funiculina*.

Bohadsch describes *Pennatula* as a deep-sea animal, which is sometimes caught "with other fishes." He notes its phosphorescent properties, to which we shall refer below, and then says * that on one occasion, in the year 1749, while sailing in the Mediterranean, he observed some phosphorescent body about four feet below the surface of the water, and being at that time "in historia naturali minime versatus" he asked the sailors what it was, and they told him that it was *Penna*, *i.e.*, a sea-pen or sea-feather.

Now Ellis avowedly obtained the greater part of his information concerning *Pennatula* from Bohadsch, and there is much reason for thinking that Dr. Grant's account is based on that of Ellis, so that it would really seem as if Dr. Grant's glowing description rests merely on a solitary observation made by a man who speaks of himself as "knowing very little indeed about natural history at the time"; an observation which consisted in looking over the side of a ship and seeing something phosphorescent in the water, whose shape he was unable to make out, but which the sailors told him was a Sea-pen.

We are accordingly of opinion that the statements concerning *Pennatula* swimming freely cannot be accepted unless fresh evidence from direct observation is brought forward.

Assuming then that *Pennatula* does not swim, there still remains the question as to what is the natural position of the pen; it undoubtedly dwells at the bottom of the sea, but is it planted upright or does it lie horizontally on the bottom?

Sir John Dalyell, a very careful observer, expresses an opinion, though by no means a decided one, that the horizontal position is the natural one. He is however much troubled by the stem, whose use on his theory he is unable to understand.† A few other zoologists have adopted this view, prominent among whom is again Dr. Grant,‡ who says: "The slow contraction of the *Pennatula phosphorea* coils up the thin flexible extremities of its calcareous axis, and moves the retroverted spines of its exterior surface so as to push the animal slowly along a rough surface."

Our own opinion is very strongly in favour of the now generally accepted view that *Pennatula* lives erect, planted in the sea-bottom. The absence of polypes on the stalk, the presence of the supporting calcareous stem, and especially the proportions of this stem in different parts of its length, and the pale colour of the stalk, speak

* Bohadsch "De quibusdam animalibus marinis," 1761, p. 107.

† Dalyell: "Rare and Remarkable Animals of Scotland," vol. ii., 1848.

‡ Grant: "Outlines of Comparative Anatomy," 1841, pp. 132-133.

strongly in support of this view, to say nothing of the evidence yielded by the undoubted fact that in *Virgularia* the stalk is known to be planted in the mud of the sea-bottom.

In connection with this question we would direct special attention to the powerful system of longitudinal muscles present in the stalk of *Pennatula*. These muscles, as previously noticed, are arranged round the stalk, not in a simple ring, but in a deeply corrugated layer, and the disposition of the muscular bands is such as to suggest the power not only of a considerable longitudinal contraction, but also of a partial lateral or spiral contraction. We are in fact disposed to view these muscular bands as affording a means whereby a slight wriggling movement of the stalk could be effected, such as would enable the *Pennatula* to burrow down into the soft mud to a certain extent; and that the pen is probably possessed of such a power is supported by the consideration that the mud in which it is planted must always be liable to be washed away by currents and other causes, in which case the *Pennatula*, if it had no power of burrowing, would fall prostrate at once, in consequence of the small total depth of its insertion in the mud. We shall return to this point when dealing with *Virgularia*.

2. *Phosphorescence*.—The majority of the *Pennatulida* are phosphorescent, and *P. phosphorea* receives its specific name from the fact that it exhibits this phenomenon in an exceptional degree.

This was well seen in the Oban specimens while living; the more perfect female specimen when suspended in a jar of sea-water in the dark, and irritated or excited by gently brushing the leaves, exhibited a fine display of phosphorescence, the different polypes when touched showing minute brilliant points of light which appeared to flash over the whole surface of the feather in rapid irregular corruscations.

Edward Forbes made some interesting observations on the phosphorescence of *Pennatula*, his main results being as follows:—The pen is phosphorescent only when irritated by touch; the phosphorescence appears at the place touched, and proceeds thence in an undulating wave to the extremity of the rachis, but never in the opposite direction; it is only the parts at and above the point of stimulation that show phosphorescence; the light is emitted for a longer time from the point of stimulation than from the other luminous parts; detached portions may show phosphorescence. Forbes also says that "when plunged in fresh water, the *Pennatula* scatters sparks about in all directions—a most beautiful sight; but when plunged in spirit it does not do so, but remains phosphorescent for some time, the light dying gradually away, and, last of all, from the uppermost polypes. One remained phosphorescent for five minutes in spirit."

Dr. Wilson,* who, at the request of Forbes, made a direct investigation of the phosphorescent properties of *Pennatula*, came to the conclusion that the phosphorescence was not an electrical phenomenon, but was probably due to some "spontaneously inflammable substance."

* Vide Johnston's "British Zoophytes," 2nd Ed., 1847, vol. i., pp. 150—155.

The most careful and systematic observations on the phosphorescence of *Pennatula* are, however, those of Panceri,* who has arrived at several results of great interest. He finds that the light emanates exclusively from the polypes and zooids, and not from all parts of these but from certain special phosphorescent organs. These "cordoni luminosi" as he calls them are eight longitudinal bands of a fatty substance, situated on the outer wall of the stomach, one band in each of the compartments of the body cavity formed by the mesenteries (Fig. 5, second section); and that these phosphorescent organs retain their luminosity after removal from the polype. Panceri states that if any other portion of a polype exhibits phosphorescence it is merely due to the special organs having been broken up, probably by the act of stimulation.

Panceri finds that phosphorescence may be excited by very various stimuli, mechanical, chemical, thermal, electrical, etc. He finds that if any point in the rachis be stimulated, luminous currents starting from the point of stimulation run both up and down the rachis and along the leaves to their extremities: and that if a leaf be stimulated the current runs down the leaf to the rachis, then both up and down the rachis and along all the other leaves to their extremities.

A further point of interest determined by Panceri is, that there is always a distinct interval between the application of the stimulus and the first appearance of phosphorescence, and that this latent period has a very constant duration of 4-5ths of a second.

It will be seen that these "phosphorescent organs" of Panceri are the same things as the "hepatic cells" of Gosse, which have been described above both in *Pennatula* and *Funiculina*.†

8.—*Geographical Distribution.*—

Pennatula phosphorea is apparently a common species at various places round the British shores: Ellis says that "great numbers have been taken on the coast of Scotland, especially near Aberdeen:" Dr. Gray mentions the coast of England and the Hebrides; and Kölliker gives as localities, besides the coast of England and Scotland, the Mediterranean, especially Naples and the Adriatic, the coast of France, and the Kattegat; to which Sars adds the whole coast of Norway, from Frederickshald to Christiansund.

* Panceri. "Etudes sur la Phosphorescence des Animaux Marins." Annales des Sciences Naturelles. Cinquième Series, Tome xvi, 1872, pp. 13–21.

† *Supra*. pp. 17 and 42.

PART III.

VIRGULARIA MIRABILIS.

LAMARCK.

Of *Virgularia mirabilis* there were obtained—

a. Seven living specimens, varying in length from six to ten inches.

b. Two bare stems, of three and six inches length respectively.

The specimens were dredged at four spots: (1) off Dunollie Castle (Station I. of the General Report of the Dredging Excursion); (2) mid-way between Lismore Point and the mainland (Station III.); (3) the southern end of Kerrera Sound (Station IV.); and (4) off Lismore Point (Station VI.). In the first of these localities *Virgularia* was taken in company with *Pennatula*; and in the second and fourth with *Funiculina*. In all four cases the depth was about twenty fathoms, and the bottom mud.

As with *Pennatula* and *Funiculina*, so also with *Virgularia*, we have found the existing descriptions and figures to be very incomplete and, with few exceptions, inaccurate as well. English zoologists have hitherto been specially culpable in this respect. *Virgularia* has long been known to be abundant at many places along the Scotch coast, and yet the stock figure of this genus given in English books at the present day is not taken from a British specimen at all, but is copied from a figure by O. F. Müller in his "Zoologia Danica," published in 1776. This figure, the first ever published from a living specimen, and which in its original form is imperfect and unsatisfactory, has been copied and recopied, losing at each operation something of what truthfulness it originally possessed, until it has culminated in the absolutely unrecognisable travesty given in Gosse's "Marine Zoology," or, worse still, in Nicholson's "Manual of Zoology," a drawing which a moment's glance at an actual specimen would have shown to be absolutely false.

Partly in the hope of removing this national reproach, and partly in the endeavour to utilise to the best advantage the specimens so freely placed at our disposal by the Birmingham Natural History Society, we have been led to attempt as complete a description of the anatomy of *Virgularia*, as the imperfect histological preservation of our material has permitted, and to illustrate our description by figures drawn with the camera from the objects themselves.

GENERAL ACCOUNT.

In general appearance, as shown in Plate IV., Fig. I., *Virgularia* is in many respects intermediate between *Funiculina* and *Pennatula*; for while it has the slender shape and proportions of the former (*cf.* Plate I., Fig. 1.), it agrees with the latter in that the polypes, instead of being inserted separately and independently into the rachis, are fused together so as to form leaves (*cf.* Plate III., Fig. 1).

As in the other two genera, so also in *Virgularia*, we distinguish a cylindrical axial portion traversed by a central calcified stem, and divisible into an upper part, the rachis (Fig. 1. *a*) bearing the polypes, and a lower part or stalk (Fig. 1. *b*), which has no polypes, and is in the natural condition planted in the sea bottom.

Concerning the stalk, however, the Oban specimens tell us nothing, for they are all broken short either at the junction of the stalk and rachis, or else some distance above this point. More than this, in addition to this imperfection at the lower end, all the specimens are imperfect at the upper end also.

All seven of the Oban specimens are, indeed, only fragments: in all cases both the tops and the stalks are wanting; in four specimens the fracture at the lower end has taken place at the junction of stalk and rachis; while in the remaining three it has occurred somewhat higher up, in the lower part of the rachis.

This mutilated condition of the specimens of *Virgularia* is a very interesting point. It might at first be thought that the Birmingham Society had for some reason or other been exceptionally unlucky, but this is not the case. The concurrent testimony of all naturalists who have dredged or described *Virgularia mirabilis* agrees in showing that this mutilation is not exceptional, but is on the contrary the almost invariable rule. Dalyell, writing on this point, says :—"Neither can I certify from what I myself have seen, or from the narrative of others, that in this country it has occurred entire and unmutilated on any occasion whatever. I have not had the good fortune of finding a representation of it in the perfect state;" * and Kölliker, our greatest authority on the whole group of Pennatulida, remarks, that of *V. mirabilis* a perfect unmutilated specimen has never yet been seen.†

Specimens with the lower end or stalk complete are very rare, but a certain number have been described and figured by Dalyell, Kölliker, and others. No description has yet appeared, so far as we can ascertain, of a specimen with the upper end perfect, and Kölliker expressly states that he has never seen one. We have had the good fortune to find one such specimen in the Glasgow University Museum, believed to have been dredged off the west coast of Scotland, but with the exact locality and date of capture unrecorded. Though perfect at the top, this specimen, which is nine inches in length, is only a partial exception to the general rule concerning mutilation, for it is broken off below at what appears to be the usual place, the junction of rachis and stalk.

* Dalyell: "Rare and Remarkable Animals of Scotland," 1848, Vol. ii., p. 181.
† Kölliker: Alcyonarien, 1872, p. 190.

From this Glasgow specimen, which will be more fully described further on, the upper part of Fig. 1 has been drawn; *i.e.*, the rachis with its leaves of polypes. The stalk in this figure is copied from a figure given by Dalyell, and is indicated with dotted lines, as we have not ourselves had an opportunity of seeing it.

The almost invariable mutilation which specimens of *Virgularia* undergo is certainly a point of great interest, more especially as it does not appear to affect either of the two allied genera, *Funiculina* and *Pennatula*, which are found living side by side with it, and may be brought up in the same haul of the dredge. We shall return to this point further on.

The polypes, as already noticed, are fused together to form leaves, and these leaves are placed in pairs along the whole length of the rachis (Fig. 1); the leaves in the middle of the rachis being further apart, and also rather larger than those at the two ends, but the difference in size being altogether insignificant in comparison with what occurs in *Pennatula* (*cf.* Pl. III., Fig. 1).

As in the two other genera, we distinguish in the rachis dorsal and ventral surfaces, the latter (Fig. 4) characterised by being bare and free from polypes along its whole length.

Imbedded in the rachis at the bases of the leaves are the zooids or rudimentary polypes, shown in Fig. 5 *e*.

The soft parts of *Virgularia*, contrary to what occurs in *Funiculina* and *Pennatula*, are completely destitute of spicules, calcification being limited to the axial rod or stem.

Anatomical Description.

1.—*The Stalk and Rachis.*—

The stalk (Fig. 1, *b*), as we have seen, is not present in any of the Oban specimens. From the descriptions and figures given by Dalyell,* Kölliker,† and Sars,‡ it appears that in the few specimens in which it has been preserved the stalk is cylindrical, with a slightly bulbous extremity; the dilated part, as in *Pennatula*, having much thinner walls than the rest.

The stalk is described as of considerable length, very much longer relatively to the whole colony than is the case in *Funiculina*. Dalyell figures a specimen in which the stalk is 8½in. long;* and both Dalyell and Kölliker agree in representing the lower end of the stalk as bent up in the manner we have indicated in Fig. 1.

The longitudinal canals of the rachis are prolonged down the stalk, according to Kölliker. In its upper part there are four main canals—dorsal, ventral, and two lateral; but in the lower part the lateral canals disappear, and the dorsal and ventral alone remain.

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* Dalyell: *op. cit.*, Plate XLIII., Fig. 7. † Kölliker: *op. cit.*, Taf. XV., Fig. 101.
‡ Sars: "Fauna littoralis Norvegiæ."

The rachis is widest at its lower end, where the polype leaves are either absent or very rudimentary (Figs. 1 and 6). As we pass upwards and the leaves get bigger, the rachis at first diminishes in width somewhat rapidly (Fig. 1), but having attained a diameter of about 0·045in. it preserves this tolerably uniformly along the greater part of its length, tapering again gradually towards the upper end. It is traversed throughout its length by four main longitudinal canals (Figs. 5 and 6 *u*), one of which is dorsal, one ventral, and two lateral; these canals, as noticed above, extending down into the stalk.

The outer surface of the rachis is an epithelial layer forming the ectoderm; and the main canals have an epithelial endodermal lining. The rest of the substance of the rachis consists of mesoderm: this is very thin opposite the bases of the leaves, as seen in the left-hand side of Fig. 5; but is of some thickness between the leaves, as shown in the right-hand side of the same figure. It is traversed by a network of very fine canals, and contains also definitely arranged muscular fibres. These latter are chiefly longitudinal in direction: they form a well-defined layer, with a crenated outline when seen in transverse section, running along the dorsal surface of the rachis a short distance below the surface epithelium (Fig. 6, *l m*), and a similar layer along the ventral surface, shown in the same figure. In the stalk, according to Kölliker's descriptions and figures, there is a continuous sheath of muscle extending all round; but in the rachis this sheath is interrupted at the sides by the polypes, and so loses its regular arrangement. The dorsal and ventral portions remain, as we have just seen, unaltered, but the lateral portions are much changed: they persist in part as the protractor and retractor muscles of the polypes (Fig. 6, *p*).

A deeper set of longitudinal muscles is developed in the lower part of the rachis in connection with the inner ends of the polype cavities: it is shown in Fig. 6.

The polype cavities communicate with the lateral canals, as shown in the right-hand side of Fig. 6; but this connection appears only to take place towards the bottom of the rachis. Through its means ova are enabled to pass from the polypes into the lateral canals.

On the ventral side of the rachis, and along its whole length, there is found a curious system of tubes, which we propose to speak of as the *radial canals*. These form two lateral masses (Figs. 5 and 6, *v c*) imbedded in the mesoderm on either side of the main ventral canal, each mass consisting of a number of branching tubes of tolerably uniform diameter, lined by a single layer of short columnar epithelial cells, which stain very readily with logwood or other colouring reagents. At intervals these tubes can be distinctly seen in transverse sections of the rachis to open into the main ventral canal, and such openings are shown in both Figs. 5 and 6.

Just before reaching the main canal the tubes are slightly constricted, and their epithelial lining suddenly changes its character, and becomes converted into the much flatter epithelium of the main canals. At their outer ends the radial canals can sometimes be traced into continuity with a system of very fine canals with no distinct epithelial lining, which branch in an irregular way through the mesoderm of the rachis, and communicate both with the polype cavities and with the main canals of the rachis, and which clearly correspond to the fine nutrient canals traversing the mesoderm of both *Funiculina* and *Pennatula*.

This system of ventral or radial canals has been described carefully by Kölliker in the genus *Halisceptrum*,* in which its main characters and relations appear to be the same as in *Virgularia*, though differing in some points of detail. We are in much doubt concerning the function of these canals. Kölliker says they are to be regarded as a modification of the nutrient canals, and possibly subserving some special function. The epithelium lining them has a very glandular appearance, and, bearing in mind their position at the points of communication between, on the one hand, the fine canal system which penetrates the mesoderm in all directions, and is in communication with the polype cavities, and, on the other hand, the main canal system of the rachis and stalk, it has occurred to us that they may very possibly be excretory organs and act as kidneys, separating effete matters from the fluid in the fine nutrient canals, and discharging it into the main canal system. This view derives some slight support from the fact that in more than one case we have seen small collections of débris over the orifices from the radial canals into the main canal, which were apparently being discharged from the former into the latter.

The chief difficulty in assigning this or indeed any other important function to this system of canals, lies in the fact that they are found only in certain members of the Pennatulida. They are present in *Virgularia* and *Halisceptrum;* but *Pennatula* and *Funiculina* have no trace of them. They can have nothing to do with the ova, for they are far too small to admit them; neither, so far as our observations go, do ova ever occur in the main ventral canal, though, as we have seen, they do pass into the lateral canals.

2.—*The Stem.*—

The stem or calcareous axis of the rachis and stalk (Figs. 2, 3, 4, 5, and 6, *c*), is cylindrical, firmly calcified, and brittle. According to Dalyell it contains as much as 85 per cent. of mineral matter, chiefly carbonate and phosphate of lime, and only 15 per cent. of animal matter.

Not only does the stem of *Virgularia* differ from that of *Pennatula* or *Funiculina* in its greater brittleness, but the proportions at various parts of its length are also very different. Both in *Pennatula* and *Funiculina* the stem is thickest at or just above the junction of the stalk and rachis, from which point it tapers both upwards and downwards, ending at both ends in fine, imperfectly calcified, and very flexible points

* Kölliker: *op. cit.*, pp. 169, 170.

(*vide* Pl. I., Fig. 2, and Pl. III., Fig. 8). In *Funiculina* the stem extends the whole length of the colony, while in *Pennatula* the stem reaches the bottom of the stalk, but stops short some distance from the top of the rachis. In *Pennatula* it is also bent back on itself at both ends in the form of a hook.

In *Virgularia* the stem (Fig. 2) extends the whole length of the colony. In the stalk, according to Dalyell, Kölliker, and Koren and Danielssen, the stem tapers gradually downwards, ending in a fine flexible point, which reaches to the bottom of the bulbous termination of the stalk, and then turns back on itself for a short distance, ending in a small hook, much as in *Pennatula*. In the rachis, starting from below at its junction with the stalk, the stem at first enlarges slightly, attaining its maximum diameter at about the point marked *c* in Fig. 2; above this point it diminishes in size, but very gradually, remaining of considerable thickness throughout the length of the rachis, and ending at its top in an abruptly truncated extremity.

In the Oban specimens the diameter of the stem at its widest part varies from 0·026in. to 0·050in.; at its upper end, which, it must be remembered, is imperfect in all the specimens, from 0·016in. to 0·039in. The average taper from the widest part of the stem upwards is ·002in. per inch length of stem.

In the Glasgow specimen of *Virgularia mirabilis*, in which the top is perfect, the upper end of the stem projects above the top of the fleshy rachis for a length about equal to its own diameter; and a similar condition has been noticed by Herklots, Koren and Danielssen, and others, in perfect specimens of allied species of *Virgularia*. The most obvious explanation of this feature is that the fleshy cœnosarc has, owing to the action of the spirit in which the specimens are preserved, contracted slightly and so left the end of the stem bare; but there appears to be some doubt as to whether this is the true one. Koren and Danielssen speak on this point as follows :—" Herklots and several others have presumed that the reason of the axis being bare at the upper end is to be sought for in a contraction of the sarcosoma under the influence of the preserving liquid: this is, however, not the case; on the contrary, we are convinced that it is a natural state, and not produced by any contraction of the cœnosarc. As well in this species (*Virgularia affinis*) as in many other genera and species, all the specimens exhibited during life the same bare axis, and likewise the sarcosoma connate with (attached by growth to) the axis at the place where the axis begins to be bare. In one specimen we even saw several *serpulæ* attached to the bare part." * This last statement is certainly strong evidence in favour of the view advocated by the Swedish naturalists, for the specimen in question was brought up living, and the *serpulæ* could not have attached themselves to the stem unless it had been already bare while in the water.

* Sars, Koren and Danielssen: "Fauna Littoralis Norvegiæ," Part 3, 1877, p. 91, note.

The present seems a suitable place to discuss further that curious mutilation of the specimens which we have seen to be so constant, nay almost universal, a feature of museum specimens of *Virgularia mirabilis*, and which applies also, though apparently in rather less degree, to other species of the genus as well.

The facts on which all authorities are agreed are the following:—

1.—The great majority of specimens of *Virgularia mirabilis* as brought to the surface by dredging are broken short at both ends.

2.—The fracture at the upper end occurs at very variable situations, but that at the lower end occurs very commonly at the junction of stalk and rachis, and nearly always within a short distance of this point.

3.—Specimens with perfect stalks are very rare, but a certain number have been obtained and described from various localities.

4.—Specimens with perfect tops appear, with the sole exception of the Glasgow specimen drawn in Fig 1, to be absolutely unknown. At any rate we have been unable to find any record of other specimens, and Kölliker, who has made a special study of the whole group, expressly states that he does not know of the existence of any.

Of these facts, acknowledged by all, no explanation has, so far as we can ascertain, been attempted hitherto. Under these circumstances we would venture to submit the following considerations. In the first place it must be borne in mind that *Virgularia* is found living alongside of two other closely allied and very similarly constituted genera, viz., *Funiculina* and *Pennatula*, and may even be brought up at the same haul with one or other of these; and yet while the specimens of *Virgularia* are invariably broken, those of *Funiculina* or *Pennatula* are as invariably unmutilated. The cause of the mutilation is, therefore, to be sought for in some one or more of those points in which *Virgularia* differs from the other two genera, and which in some way or other determine that it shall be broken, while the allied forms remain entire.

Now the chief points of contrast between *Virgularia* on the one hand, and *Funiculina* and *Pennatula* on the other, are—

1.—The great brittleness of the stem of *Virgularia*, and the fact that, instead of tapering upwards to a fine flexible point, it remains of considerable thickness up to the very top of the rachis.

2.—The length of the stalk in *Virgularia*, and its strongly marked hook-like termination. The stalk is much longer relatively than that of *Funiculina*, and is much longer absolutely than that of *Pennatula*.

We *know* from the observations of Rumph and Darwin, to be noticed further on, that *Virgularia* lives with the stalk planted in the sea bottom, and the rachis freely projecting above it; and from an observation of Captain Lancaster's * it appears to require a tolerably firm pull to draw out a *Virgularia* from its hole.

* Kerr's "Collection of Voyages," vol. viii., p. 119. Quoted in Darwin's "Naturalist's Voyage round the World."

We would therefore suggest that the fracture at the lower end is caused at the time of capture, and is due partly to the brittleness of the stem, and partly to the firm implanting of the stalk in the sea bottom. The usual site of the fracture—at the junction of rachis and stalk (*vide* Fig. 1)—strongly supports this view, for while on the one hand the dredge dragging along the bottom would snap off the stem exactly at this point, on the other the tangles brushing against the rachis higher up would bend and break it at the very same spot, *i.e.*, its point of emergence from the ground. Knowing as we do that *Virgularia* when living undisturbed not only has the stalk, which is wanting in almost all dredged specimens, but also that the stalk is buried completely in the sea bottom, this part of the explanation seems to us entirely satisfactory.

Concerning the fracture of the upper end, however, the case is different. The cause here must be an altogether different and independent one. It is almost inconceivable that any influence at the time of capture could invariably break off the tops of the specimens. Neither the dredge, nor the rope, nor the tangles, could, so far as we can see, possibly effect this fracture: their tendency would always be, as we have just shown, to break the stem at its point of emergence from the ground. We are, therefore, driven to the conclusion that the upper fracture is not effected at the time of capture, but that *Virgularia*, while living undisturbed at the bottom of the sea, has already lost its top. This is confirmed by an observation of Darwin,* who describes the *Virgularia* (*Stylatula Darwinii* of Kölliker) seen by him living on the shores of Patagonia as truncated at the upper end.

Having thus narrowed our problem and defined its limits more precisely, we have now to determine, if possible, what are the causes which, acting normally during the life of a *Virgularia*, and quite independently of any influence exerted by man, lead to the almost invariable truncation of its upper end.

The first explanation that suggested itself to us was, that in the ordinary course of growth the top, after attaining its full development, dies, withers up, and drops off, and in this way causes the truncation. This is at first sight an attractive theory, and accords well with the fact that the leaves at the bottom of the stalk are always small and immature, and gradually increase in size and development as we pass upwards; *i.e.*, that the development of leaves appears to proceed from below upwards.

However, closer examination reveals fatal objections to this view. In the first place the actual upper ends of the specimens as dredged, show no sign whatever of disease, or of being about to perish. On the contrary, in all the specimens examined the rachis is perfectly healthy right up to the top. Secondly, the truncation does not occur always at or about the same spot in different specimens, but at

* Darwin: "Naturalist's Voyage Round the World," 1860, p. 99.

various points of their length. In some (*cf.* Fig. 1) it occurs above the largest leaves, in others some way below them, and in others again about the position of the largest leaves; *i.e.*, the widest part of the rachis. This variability is certainly not what we should expect were the truncation due to death from natural causes. Thirdly, even though it were true that the polypes after living a certain time died and withered away at the top of the rachis, *this would not account for the stem being invariably broken off at the junction of living and dead polypes.* This stem contains, as we have seen, as much as 85 per cent. of mineral matter, and it could hardly be maintained that the death of the polypes encrusting it would so affect the stem as to cause it to continually break off at the exact boundary line between living and dead polypes. The fact that the stems are frequently dredged up of dead specimens, from which the whole of the animal matter has been removed by decomposition, and which stems are very slightly if at all more brittle than stems of living specimens, proves conclusively that death of the polypes would not in any way cause or account for truncation of the stem as well. We are therefore compelled to reject this explanation altogether; firstly, because it has not been proved to be a true cause, for we have no evidence at all that the top does actually die down as suggested; and, secondly, even if a true cause, it is an insufficient one, because it leaves completely unexplained the truncation of the stem as well as of the soft parts.

If the cause of the truncation then does not lie in the *Virgularia* itself, it must be some force acting on it from without. Fish or other marine animals knocking up against the colonies, and so breaking them off, could not account either for the invariable occurrence of the truncation or for its situation, for lateral blows would tend to cause fracture not high up the rachis, but, as already explained, at the point of emergence from the ground; *i.e.*, junction of rachis and stalk.

The only other explanation that occurred to us, and the one we advanced when presenting our report to the Birmingham Natural History Society on June 20th, is that the truncation is due to the tops being habitually bitten or nibbled off as food by some marine animals, most probably fish. At the time of presenting our report, this explanation was offered as a pure hypothesis, in support of which we had no direct evidence, and to which we were driven simply from inability to conceive of any other that would satisfy the conditions of the problem. Since this time we have been fortunate enough to obtain direct evidence of a very striking and satisfactory nature in support of our view.

Mr. R. D. Darbishire, of Manchester, to whom we mentioned the difficulty, told us he remembered many years ago taking specimens of *Virgularia* from the stomach of a haddock caught off Scarborough. Fortunately these specimens, which bear the date of the 9th November, 1855, were preserved, and Mr. Darbishire has very kindly handed them over to us for examination. They consist of five fragments of

Virgularia mirabilis, from three quarters of an inch to three inches in length, each fragment containing the portion of stem belonging to it, and all five showing evident signs of having undergone partial digestion.

The most interesting point still remains to be noticed. Of these five fragments no fewer than three are *tops*, *i.e.* actual perfect upper ends, a point the significance of which is at once evident when we remember that of the specimens of *Virgularia mirabilis* dredged either off our own coast or elsewhere, only one single specimen—the one in the Glasgow Museum—is known to have a perfect top.

Mr. Darbishire's observation proves that fish do actually bite off and swallow as food fragments of *Virgularia*; also that they are able to find specimens with perfect tops, for which tops they would appear to have some special liking. It need hardly be pointed out that this furnishes the strongest possible confirmation of the theory we had been led to frame on purely independent grounds.*

Two points still require explanation. Firstly, why, if the fish bite off the tops and swallow them as food, do they not devour the whole of the rachis as well? Secondly, why do the fish eat the tops off *Virgularia* and leave untouched the allied genera, *Pennatula* and *Funiculina*, which are found growing alongside it, and of which the latter, at all events, would appear to be far more tempting as food, owing to the much greater bulk of fleshy substance it affords, and the much smaller thickness of its stem in the upper part. If it be supposed that the calcareous matter of the stem is the real attraction to the fish, it is difficult to understand why *Pennatula*, with its innumerable calcareous spicules, is allowed to escape.

We shall return to both these points further on.

3.—*The Polypes and Zooids.*—

The general arrangement of the leaves is shown in Fig. 1; and the leaves, together with the polypes of which they are formed, in Figs. 3, 4, and 5. In the Oban specimens each leaf is formed by the fusion of seven to eight polypes, placed side by side, the number being constant in all the leaves of any one specimen, but varying in different specimens. The leaves are arranged strictly in pairs at the two ends of the rachis, but about its middle often show slight irregularities, and may even alternate with one another for some little distance.

At the bottom of the rachis there is no trace of leaves or polypes, but about an eighth of an inch higher up the leaves begin to appear as small transverse ridges: they are at first very close together, and the component polypes very small; but passing upwards the polypes gradually get larger and the leaves wider apart. Having reached their maximum size and distance from one another, the leaves preserve these for some distance, and then, towards the top of the rachis, begin gradually to get smaller and closer together.

In the Glasgow specimen, which has the rachis perfect at both top and bottom, we have been able to measure accurately the number of

* Professor M'Intosh also mentions finding *V. mirabilis* "occasionally in the stomach of the cod."

leaves in each inch length of the rachis. In the following table these numbers are shown, as well as the "pitch" of the leaves at different parts of the length. By "pitch" we mean the number of pairs of leaves per inch length of rachis; *e.g.*, if in a given inch there are nine pairs of leaves, then the "pitch" at that part of the rachis is 9; or again, if in a given quarter of an inch there are four pairs of leaves, this is at the rate of sixteen pairs in an inch, which is expressed by saying that the "pitch" at this part is 16.

The total length of the rachis in the Glasgow specimen is 9 inches, and the pitch at different parts is as follows, commencing at the upper end:—

First inch	—first $\frac{1}{8}$ inch ..	9 pairs of leaves;	*i.e.*, pitch 72
	second $\frac{1}{8}$,, ..	6 ,, ,,	,, ,, 48
	second $\frac{1}{4}$,, ..	4 ,, ,,	,, ,, 16
	second $\frac{1}{2}$,, ..	7 ,, ,,	,, ,, 14
Second ,,	.. .. ..	9 ,, ,,	,, ,, 9
Third ,,	.. .. ..	8 ,, ,,	,, ,, 8
Fourth ,,	.. .. ..	$7\frac{1}{2}$,, ,,	,, ,, $7\frac{1}{2}$
Fifth ,,	.. .. ..	$7\frac{1}{2}$,, ,,	,, ,, $7\frac{1}{2}$
Sixth ,,	.. .. ..	8 ,, ,,	,, ,, 8
Seventh ,,	.. .. ..	11 ,, ,,	,, ,, 11
Eighth ,,	.. .. ..	18 ,, ,,	,, ,, 18
Ninth ,,	—first $\frac{1}{2}$ inch ..	12 ,, ,,	,, ,, 24
	third $\frac{1}{4}$	17 ,, ,,	,, ,, 68

Lower than this the leaves could not be accurately counted without putting the specimen under the microscope, which we had no opportunity of doing. In Fig. 1, which is drawn from the Glasgow specimen, the numbers along the left-hand side of the figure indicate the pitch at the points opposite which they are placed; the number 48, for instance, near the top of the figure, indicating that the pitch at this point is 48—*i.e.*, that at this point the leaves are at the rate of 48 to the inch.

In the Oban specimens the tops are wanting, but the lower ends of the rachis are, in four out of the seven specimens, perfect; and in these we have measured the pitch at different points, in order to compare with the Glasgow specimen. In one specimen which we select as apparently a fairly typical one, the total length of rachis is, as in the Glasgow example, nine inches; but as the top has gone, the specimen when entire must have been considerably longer. The measurements of this specimen are as follows, commencing at the upper (truncated) end:—

First inch	.. .. ..	6 pairs of leaves;	*i.e.*, pitch 6
Second ,,	.. .. ..	6 ,, ,,	,, ,, 6
Third ,,	.. .. ..	6 ,, ,,	,, ,, 6
Fourth ,,	.. .. ..	7 ,, ,,	,, ,, 7
Fifth ,,	.. .. ..	9 ,, ,,	,, ,, 9
Sixth ,,	.. .. ..	12 ,, ,,	,, ,, 12
Seventh ,,	.. .. ..	15 ,, ,,	,, ,, 15
Eighth ,,	.. .. ..	23 ,, ,,	,, ,, 23
Ninth ,,	—first $\frac{1}{2}$ inch ..	16 ,, ,,	,, ,, 32
	third $\frac{1}{4}$,, ..	12 ,, ,,	,, ,, 48

A comparison of this with the other Oban specimens has led us to a few general results of some interest. In the first place, we find that in no one of the specimens is the pitch at any part less than 6; *i.e.*, in no part are there less than six pairs of leaves in an inch length of rachis. We have already seen that the largest of the leaves are those which are furthest apart, so that it would appear that, so far as the Oban specimens are concerned, the limits of growth of the leaves are reached when these have attained a distance from one another of $\frac{1}{6}$ in. In the table given above it will be seen that when this point has been reached growth stops, and in the upper three inches the pitch remains constant at the number 6; and the same thing applies to the other specimens as well. Secondly, in five out of the seven specimens the pitch at the upper end is 6, while in the remaining two specimens it is 8. If, as we have tried to show above, this number 6 is the limit, and is only reached in those parts which have attained their full growth; *i.e.*, in the parts at or about the middle of the entire colony (*cf.* Fig. 1), then these facts would seem to show that the tops are usually bitten off somewhere about, perhaps slightly above, the middle; *i.e.*, that in the Oban specimens at any rate, the rachis, if complete, would be something like double its actual length. Concerning the growth of the leaves it is clear that, as in *Pennatula*, the seat of development of the leaves is at the lower end of the rachis.

Although the leaves get smaller and closer together towards both upper and lower ends of the rachis, yet there is a great difference between the two cases. At the upper end, just as in *Pennatula*, though the leaves get smaller the polypes remain fully formed—a point we have been able to confirm by an examination of the specimens taken by Mr. Darbishire from the haddock's stomach. At the lower end of the rachis on the other hand, not only do the leaves get smaller, but their component polypes get more and more imperfect, and at last (Fig. 6, *dr*) become reduced to mere pit-like depressions of the surface.

We conclude, therefore, that the topmost leaves are the oldest, the lowermost the youngest: that the seat of development of the leaves is the lower end of the rachis; and that each actual leaf takes its rise at this point, and gradually travels upwards as new leaves are developed in succession below it; that the colony grows along its entire length, but that the limit of growth is reached, as already explained, when the distance between successive leaves amounts to $\frac{1}{6}$ inch: that this limit is never reached by the oldest or uppermost leaves, which remain permanently small and close together, but that as the colony gets older and older the pitch finally attained by the leaves gradually diminishes until its final limit is reached.

It follows from this that all the part of a *Virgularia* above the point at which this final pitch is first attained has ceased to grow: and the part below it is still growing, but will cease to do so as soon as this limit is reached.

It will be seen that in many respects this mode of growth agrees closely with that we have described in *Pennatula*. In both cases the point of origin of new leaves is the bottom of the rachis, and in both we have the same arrest of development after reaching a certain limit.

In *Virgularia*, however, the successive leaves tend to separate from one another to a far greater extent than they do in *Pennatula*, while in the latter the lateral growth of the individual leaves is very much greater than in *Virgularia*. Another point of difference lies in the fact that while in *Pennatula* the several polypes of a leaf are developed successively, in *Virgularia* they appear simultaneously, the youngest leaves having the same number of polypes as the oldest or most mature ones.

Concerning the calcified stem it is clear that it also must grow so as to keep pace with the whole colony. From its extremely dense structure and the very large proportion of inorganic matter it contains, it seems very improbable that it can grow interstitially along its whole length; indeed, it appears almost certain that growth only occurs by the addition of new matter, either at the ends or on the outside of that which is already formed. If it be also true, as noticed previously, that the top of the stem normally projects bare for a short distance above the top of the rachis, then it is clear that the stem can only grow in length by addition to its lower end *i.e.*, that it is continually being pushed up, as it were, through the rachis from below, and that the growth of the stem in length, though not in thickness, is independent of that of the rachis. Increase in thickness is effected by the deposition of successive laminæ one outside another by the soft tissues of the rachis and stalk in contact with the stem.

Though the several polypes of each leaf come into existence simultaneously, and in the smallest leaves the number of polypes is the same as that in the most fully developed ones, yet we find that from the time of their very first appearance there is a gradual increase of size as we pass from the most dorsal polype of a leaf towards the most ventral one. This is shown clearly for the fully developed leaf in Fig. 5, and for the early stages of development in Fig. 6.

This difference in size between the dorsal and ventral polypes of a leaf might be explained, so far as the adult leaves are concerned, by the greater freedom and range of action, and consequent greater chances of obtaining food possessed by the ventral as contrasted with the dorsal polypes; but this explanation would hardly account for the difference in size being so marked in the very earliest stages of their development. We are disposed to think that the true explanation is that in the ancestral forms either of *Virgularia* itself, or from which *Virgularia* was derived, the several polypes were, as in *Funiculina* and *Pennatula* at the present day, developed not simultaneously but successively one above another, the ventral ones first; and that though *Virgularia* has lost this primitive character, and has acquired the habit of developing all the polypes of a leaf simultaneously, it has still retained indications of its ancestral habits in the greater size of the ventral polypes, even in their earliest stages. It is just possible that more careful examination than we have had the opportunity of making would show that the ventral polypes actually appear slightly before the dorsal ones, which would completely prove our case. We shall find further on additional evidence that *Virgularia* is less primitive than either of the two other allied genera, *Funiculina* or *Pennatula*.

The dorsal polypes of each pair of leaves are (as shown in Figs. 3 and 5) separated from one another by a very short interval at their bases, while the most ventral polypes (Figs. 4 and 5) are separated by the whole width of the ventral surface of the rachis. In this respect *Virgularia* agrees with both the other genera.

The Zooids in *Virgularia* are exceedingly rudimentary; more so even than in *Pennatula*. They form small pit-like depressions on the sides of the rachis, placed in somewhat oblique rows at the bases of the leaves (Fig. 5 *e*).

4.—*Anatomy of the Polypes.*—

The polypes of *Virgularia* as might be expected are essentially similar to those of *Funiculina* or *Pennatula*; resembling, owing to their fusion into leaves, those of the latter rather more closely than the former genus.

The structure of the adult polypes is shown in Figs. 5 and 7, the former figure representing the seven polypes composing a leaf in their natural relation to one another and to the rachis; while the latter figure represents transverse sections of three polypes taken at different parts of their length, the upper section passing through the stomach and the base of the tentacles; the middle section through the mesenterial filaments immediately below the stomach; and the bottom section passing through the lower part of the body cavity, not far from the rachis.

Taking the component parts of the polypes in the same order as in the other two genera, we have to deal first with

a. The Body-wall: consisting of a firm gelatinous mesoderm (Fig. 7, *x*) covered on its outer surface by the ectoderm, *w*: and on its inner by the endoderm, *y*. Ectoderm and endoderm each consist of a single layer of epithelial cells, while the mesoderm is traversed by branching nucleated cells, and also by fine tubular channels, in connection with those of the rachis.

This mesoderm is tough, and has considerable powers of resistance to re-agents; it gives their definite shape to the polypes; and in specimens of *Virgularia* taken from a haddock's stomach at Scarborough in a partially digested condition, the mesoderm alone had escaped, ectoderm, endoderm, and all the internal organs being in most cases dissolved out completely.

At their lower ends the polype cavities (Fig. 5) are, as in *Pennatula*, separated by only very thin partitions from the main dorsal and lateral canals of the rachis; while the curious system of radial canals, (Fig. 5, *rc*) as already noticed, communicates with the body cavity of the most ventral polype of the leaf.

We have not noticed any perforations in the walls separating the several polypes of a leaf from one another, such as are described and figured by Kölliker as occurring in *Halisceptrum* and other genera.

The body-walls of *Virgularia*, as already noticed, contain no spicules; differing in this respect most markedly from those of *Pennatula*.

b. The Calyx.—This forms (Fig. 5, *g*), a wall surrounding the tentacles when these are either partially or wholly retracted. It differs from the calyx both of *Funiculina* and *Pennatula* in several respects. It has no strengthening spicules, and it is not produced at its margin into pointed processes, alternating with the tentacles, as is the case in the other two genera. The most important point of difference, however, lies in the fact that while in *Funiculina* and *Pennatula* the calyx is a permanent fold of the body-wall, in *Virgularia* it is only a temporary one and disappears altogether when the tentacles are fully expanded. This will become clear at once from an examination of Fig. 5, in which the several polypes of the leaf are drawn in different stages of expansion or contraction. Thus the second and seventh polypes, numbering them in order from the dorsal to the ventral surface, are shown almost completely retracted, and in these the calyx forms a deep fold of the body-wall surrounding the whole length of the tentacles. In the third and fifth polypes the tentacles have commenced to protrude, and it will be seen that as they rise up the calyx wall unfolds with them. In the sixth polype the tentacles are almost fully expanded, and the calyx is now reduced to a very low wall surrounding their bases. The fourth polype is drawn in a fully expanded condition, and it will be seen that the calyx (Fig. 5, *g*), is completely unfolded, and has in fact ceased to exist; its position being indicated only by a slight wrinkling of the body-wall at the base of the tentacles, and even this disappearing in extreme protrusion of the tentacles.

If this figure be compared with those already given of *Funiculina* (Plate II., Fig. 10) and *Pennatula* (Plate III., Fig. 4), it will be seen that the calyx is formed in exactly the same way in all three cases, by an infolding or inversion of the upper end of the body-wall; and that the difference, which is clearly connected with the existence or non-existence of spicules in the calyx, lies in the fact that in *Virgularia* this calyx-fold is completely everted and straightened out when the tentacles are fully expanded, while in the other two genera it is only partially so, the fold being to a certain extent permanent, the calyx still persisting even when the tentacles are protruded to their utmost extent.

c. The Tentacles (Fig. 5) are very similar to those of the other two genera. They form a whorl of eight hollow processes arranged round the mouth, each bearing along its inner edge a double row of pinnules. Each tentacle consists of an outer layer of ectoderm cells continuous with those of the body-wall, a middle layer of mesoderm cells, consisting chiefly of muscular fibres arranged in an outer longitudinal and an inner circular layer, and an inner lining of endoderm cells continuous, as is seen in the fourth polype of Fig. 5, with the endoderm lining the body-cavity of the polype.

Our specimens of *Virgularia* are in rather worse histological condition than those of either *Funiculina* or *Pennatula*, and we have been unable to determine with certainty whether thread-cells, the special defensive and offensive weapons of *Cœlenterata*, are present or absent. The point is one of some importance; for should they prove to be absent we might find in this the explanation of *Virgularia* being habitually devoured as food, while *Funiculina* and *Pennatula* are allowed to go unharmed.

This explanation is of course a purely hypothetical one, resting merely on our inability to find thread-cells in imperfectly preserved specimens. We have thought it worth while to record it, however, as it is one which the Society may have an opportunity at some future time of testing directly, and also because there are certain other facts which seem to make it not altogether improbable. Thus we know from the observations of Kölliker, Koren and Danielssen, and others, that the truncation of the upper end occurs normally in certain species of *Virgularia*, but not in others; *i.e.*, according to our theory, that certain species of *Virgularia* are habitually eaten as food by fish or other marine animals, while other species escape. We know also from an observation of Rumph made more than a century ago, that some species of *Virgularia* possess a very remarkable power of stinging, due evidently to the possession of thread-cells, while in other species this stinging power is not perceptible, at any rate to ourselves.

Rumph's observations are so important that we shall quote them here. His specimens of *Virgularia*, of a species which has been since named by Kölliker, in honour of its discoverer, *Virgularia Rumphii*, were obtained at Amboyna, a small island in the Malay Archipelago, east of Celebes. Concerning them, he says:*—" If one handles them incautiously one experiences a burning sensation, and the hand becomes red; then ensues a violent itching, followed by the appearance of blisters, as if one had been stung by nettles, lasting for three days." Concerning another species, *Virgularia juncea*, Rumph remarks that he has not noticed that it causes any distinct burning or itching in the hand, although he had pulled them up by hundreds. Neither does Darwin, in his account of the South American *Virgularia*, say anything concerning it possessing a power of stinging, which he could hardly have failed to notice had it been actually present. We know also that both of these latter species are habitually truncated, so that there seems sufficient evidence to warrant our making the suggestion that *Virgularia mirabilis* may be devoured because it possesses no thread-cells, while *Funiculina* escapes because it is richly armed with these defensive weapons.

* Rumph: "T' Amboin 'sche Rariteitkamer," p. 43, Amsterdam, 1741.

d. The Stomach.—The mouth, as shown in Fig. 5, *m*, is situated on the apex of a small papilla that rises up in the middle of the circle of tentacles, the outer wall of the papilla being continuous with the bases of the tentacles and the inner with the wall of the stomach. The mouth is a transverse slit (Fig. 7), whose long axis is at right angles to the flat surface of the leaf. The varying position of the mouth in different conditions of protrusion or retraction of the polype is well shown in the several polypes of Fig. 5. When the tentacles are completely retracted, as in the second and seventh polypes, the mouth is some considerable distance below the margin of the calyx, while in the fully expanded fourth polype the mouth is seen to be some distance above the calyx margin.

The mouth leads by a narrow œsophageal passage into the thick-walled stomach (*n*), which is thrown into folds closely similar to those of *Funiculina* or *Pennatula*. The concertina-like action of these folds as the polype is expanded or retracte l is well shown in Fig. 5; in the retracted polype the folds of the stomach are closely pressed together, and the whole stomach is very short: when, on the other hand, the polype is protruded, the folds of the stomach-wall are pulled out, and the whole organ becomes at least double its previous length.

As in the other two genera the stomach-wall consists of a thick inner lining of ectoderm cells, a thin mesodermal layer, and a fairly thick outer coat of endoderm cells continuous with those lining the body-cavity.

e. The Mesenteries, like those of *Funiculina* and *Pennatula*, are eight vertical partitions or septa, uniting the body-walls and stomach together, and extending below the latter down to the bottom of the polype-cavity.

Round the stomach the mesenteries are arranged at nearly equal intervals, two being attached to the upper surface of the leaf, two to the lower, and two to each of the partition walls separating the polype from its neighbours on either side. Below the stomach the arrangement becomes asymmetrical, in the manner already described as occurring in *Pennatula*; *i.e.*, the two mesenteries attached to the upper surface of the leaf retain their position, or even move slightly away from one another, while the lateral ones shift downwards towards the lower surface. This change of position is well shown in the two lower sections of Fig. 7, which show also that while the upper two mesenteries remain of some width the whole way down the polype, the other six become very soon reduced to mere ridges.

The arrangement of the muscles in the mesenteries is the same as in the other two genera. The strong retractor muscles (*p*), by which the polype and tentacles are withdrawn into the calyx and the folds of the stomach approximated to one another, are shown in the several polypes of Fig. 5.

f. The Mesenterial Filaments.—Here again the arrangement is closely similar to that of *Funiculina* or *Pennatula*; as in these genera, there are in each polype six *short mesenterial filaments* (Figs. 5 and 7 *r*).

which are thickenings on the edges of the lateral and under pairs of mesenteries, and which, commencing at the lower end of the stomach, only extend a short way down the polype cavity; and two *long mesenterial filaments*, formed on the edges of the upper pair of mesenteries (Figs. 5 and 7 *s*), and extending down quite to the bottom of the polype cavity. All the mesenterial filaments are much convoluted, and the two long ones are much thicker than in either of the other two genera.

We have obtained evidence concerning the digestive function of these mesenterial filaments of a precisely similar nature to that already brought forward in the case of *Pennatula*; *i.e.*, we have found foreign bodies, such as diatoms (Fig. 7, *fo*), imbedded in the filaments, and clearly undergoing digestion. As these bodies become completely enveloped in and by the filaments, it is clear that these latter must have the power of changing their shape and spreading round any body that may come in contact with them, a power that is probably due to amœboid movements of the individual cells of the filaments.

We described in *Pennatula* the presence of an Entomostracon, apparently a parasitic Copepod in the body-cavity of one of the polypes; and we noticed also that ripe ova had been discharged from the Entomostracon and were lying in various parts of the polype, some freely and some imbedded in the mesenterial filaments; also, that many of these ova had commenced to develop.

We have found ova precisely similar to these present in large numbers in the polypes of *Virgularia* (Fig. 7, *ov*), and although we have not found the Entomostracon itself, we have no doubt, from the identical character of the eggs in the two cases, that those found in *Virgularia* belong to the same animal as those found in *Pennatula*, or to some very closely allied one.

We have also found, what we were not aware of when writing our account of *Pennatula*, that Entomostraca very closely similar to this one have already been discovered in corresponding situations in allied animals.

In 1859 Bruzelius* described under the name of *Lamippe rubra* a parasitic crustacean which he found inhabiting specimens of *Pennatula rubra* taken off the west coast of Sweden. Not long afterwards Claparède† found at Naples an allied form, which he called *Lamippe proteus*, dwelling parasitically in specimens of *Lobularia (Alcyonium) digitata*, and wrote a careful account with figures of both the male and female.

Quite recently M. Joliet‡ has described and figured a third species of this genus obtained from *Paralcyonium elegans*, and which he names *Lamippe Duthiersii*. He notices, like Claparède, that the sexes are distinct, and lays stress on the remarkable changes of shape which the

* Bruzelius: "Ueber einen in der *Pennatula rubra* lebenden Schmarotzer." (Archiv. f. Naturgesch, 1859, bd. i., p. 286.)

† Claparède: "Miscellanées Zoologiques," "Annales des Science Naturelles," "Cinquieme Série," tome viii., 1867, p. 23 *seq.*

‡ Lucien Joliet: "Observations sur quelques Crustacés de la Mediterranée," "Archives de Zoologie experimentale" tome x., 1882, p. 101 *seq.*

body undergoes, and which led Claparède to name his species *L. proteus*. When at rest the animal is a somewhat cylindrical sac, about 0·01 inch in length, with two pairs of jointed antennæ at its anterior end in front of the mouth; two small pairs of legs a short way behind the mouth; a caudal-fork armed with setæ; and a straight alimentary canal with a distinct anus.

The Entomostracon we found, as described above, in *Pennatula* clearly belongs to the same genus. Unfortunately we have as yet come across only a single specimen, and as that one is in a series of transverse sections it is impossible to make out all its characters. It, however, does not agree with either of the species already described, and is probably an additional species of this curious genus, and one which we name provisionally *Lamippe Pennatulæ*.

Concerning the relations of *Lamippe* to the polype it inhabits, we were in doubt when describing *Pennatula* whether to regard it as a parasite or as an animal swallowed as food: it would appear now, from the additional evidence that has since come into our hands, that it is a true parasite. We have already mentioned that the eggs develop up to a certain stage within the polype, and Joliet has shown that they hatch in this situation and then escape as free swimming *Nauplii*. We have found numerous empty egg-shells, but have seen no free *Nauplii*.

g. The Reproductive Organs.—The eggs in *Virgularia* occupy a very different position to that they hold in *Funiculina* or *Pennatula*. They are confined to the lower part of the rachis, and only occur in that part of it in which the polypes are either absent or very immature. In this lower part of the rachis, a transverse section across which is represented in Fig. 6, the canal system of the mesoderm becomes very greatly developed. In addition to the four main canals (*u*) there are large lateral chambers lined by endoderm, and from this endoderm at certain places the ova (*t*) are formed, and when ripe fall into the chambers, in which they lie free.

The actual development of the ova themselves is much the same as in the other two genera. Each ovum is a single endoderm cell which becomes bigger at the expense of its neighbours, rises up from the surface to which it remains attached by a stalk or peduncle, developes a firm protective capsule round itself, acquires a large germinal vesicle with included germinal spot—the nucleus and nucleolus respectively of the original endodermal cell—and having attained its full size becomes detached from the stalk and lies free in the chamber of the rachis. How the eggs get out ultimately we have been unable to determine with certainty; most probably their exit is effected through the mouths of the polypes higher up the rachis, whose body-cavities are in connection with the large chambers of the lower or ovarian end of the rachis.

The essential difference between *Virgularia* on the one hand, and *Funiculina* and *Pennatula* on the other, so far as their reproductive organs are concerned, lies in the fact that while in the latter two genera the reproductive elements, ova or spermatospheres, are developed within the polypes, in *Virgularia* they are formed independently of the polypes, and in a part of the rachis where the polypes are either altogether absent or at least very immature.

It will be remembered that in *Funiculina* we described and figured the occurrence of ova in the canal system of the rachis (Plate II., Fig. 10, *t*), and left it uncertain how these ova got into canals which, except at the points where they lie, are much too small to admit them. The condition of things in *Virgularia* renders it not improbable that these ova have originated and been developed in the position in which we find them within the canals.

All the four Oban specimens in which the lower end of the rachis is perfect, prove on examination to be females, so that we have had no opportunity of investigating the development and relations of the male organs. We regret this the more because the descriptions we possess of these organs are not in all respects satisfactory.

Young ova in the earlier stages of development are only found at the very bottom of the rachis, or, at any rate, only where the polypes are very immature; they are also far more abundant in the ventral than the dorsal half of the rachis, if, indeed, they are not confined to the former. Mature ova—*i.e.*, eggs which have reached their full size and become detached from their stalks, are found extending much higher up the rachis, and may occur in the body-cavities of fully-developed polypes.

If it is borne in mind that each leaf commences its existence at the bottom of the rachis, and is gradually forced upwards by the successive development of new leaves below it, it will be seen that each leaf in the early stages of its existence has fully-developed reproductive organs, but no organs for digestion of food or capture of prey; and that in the later stages of its life it loses its reproductive organs and develops prehensile and digestive organs. In other words, the two great functions of nutrition and reproduction, which are carried on simultaneously in the polypes of *Funiculina* and *Pennatula*, occupy in *Virgularia* different phases of the life-history of the polypes, and strangely enough the reproductive phase precedes the nutritive; the polypes develop reproductive organs and products while they are yet unable to catch or digest food for themselves, and by the time they have acquired organs for these latter purposes the reproductive organs have disappeared.

In presenting this separation of their life-history into two distinct chapters, as it were, the polypes of *Virgularia* are less primitive, and more specialised, than those of either of the other genera with which we have been dealing.

None of the ova that we have examined from the Oban specimens have even commenced to develop, so that we can give no account of the processes of development from our own observations. Dalyell, who kept *Virgularia* in captivity for some months, informs us * that

* Sir John Graham Dalyell: "Rare and Remarkable Animals of Scotland," vol. ii., p. 188, 1848.

during May and June he found numbers of eggs at the bottoms of the glasses in which he kept his specimens; that from these eggs larvæ in the form of free-swimming ciliated planulæ were developed, which after a time attached themselves by one end and produced tentacles, a stomach, and four septa. He kept these young specimens for a month without their undergoing any further change.

By means of fertilised ova and the free-swimming larvæ to which they give rise new colonies of *Virgularia* are started. Increase in size of the colony, when once started, is effected by the formation of leaves one below another, as already noticed. The actual process of formation of the polypes is easier to study in *Virgularia* than in the other genera, because by making a series of transverse sections through the lower end of the rachis at different levels all the successive stages of development can readily be obtained from a single specimen.

At the very bottom of the rachis there is no trace of polypes at all, and at this part the fleshy substance of the rachis, which is here of considerable thickness, is hollowed out to form the large lateral chambers already described.

A little higher up we get the first rudiments of the polypes. These appear as transverse rows of small pit-like depressions of the superficial layer of ectoderm which clothes the whole rachis (Fig. 6 *dr*). Each pit opens by its mouth on to the surface; its inner end, which is closed, projects somewhat into the lateral chambers of the rachis, as shown in the figure. Each of these pits will become the stomach of a polype, the mouth of the pit remaining as the mouth of the polype.

We have already said that the pits are arranged in transverse rows; each row is situated on one of the slightly marked transverse ridges which mark the commencing leaves at the bottom of the rachis; and in each row there are seven or eight polypes according to the number present in the fully developed leaves of the same individual. In each row, also, the polypes gradually increase in size from the dorsal to the ventral surface.

A little higher up in the rachis, *i.e.*, at a slightly later stage of development, we find the pits somewhat deeper; we find, also (Fig. 6), that the lateral chambers have become divided by radial partitions into smaller chambers, one for each pit, which become the body-cavities of the polypes. These body-cavities grow up round the pits, leaving them attached to what are now the body-walls of the polypes by the eight septa or mesenteries. Round the mouths of the pits a series of small buds begins to appear, the rudiments of the tentacles.

The constrictions separating the leaves from one another become more and more marked, so that the leaves gradually acquire independence of one another; the tentacles grow rapidly in size, and develop along their inner borders the pinnules; the walls of the pits, or the stomachs of the polypes, become thrown into the folds characteristic of the adult polypes, and the bottoms of the pits become perforated, thus placing the stomach-cavities in communication with the body-cavities; and then the extension of the mesenteries to the bottom of the polype-cavities, and the thickening of their free edges to form the mesenterial filaments, are all that is necessary to complete the development of the polypes.

We shall only notice one other point: the great retractor muscles of the polypes appear at a very early stage, when the stomach cavities are mere pits and no traces of the tentacles have yet appeared. They are shown at about this period in Fig. 6, *p*. By studying the early stages carefully it can be seen that these muscles are portions of the great subcutaneous system of muscles which originally extended all round the rachis, and which persists comparatively unaltered on the dorsal and ventral surfaces (Fig. 6, *lm*), portions the direction of which has become changed by the pittings in of the surface which form the stomach-cavities of the polypes.

From the mode of formation of the body-cavities of the polypes out of parts of the canal system of the rachis, it is clear that the continuity between these two systems which we have seen persists in the adult is a primitive one, and not a secondary one acquired in the course of development.

5.—*Anatomy of the Zooids.*—

The zooids of *Virgularia* are simply arrested polypes, polypes which have stopped short at the stage of development represented in Fig. 6. They have no tentacles; their stomach-cavities are merely blind sacs, the walls of which are not thrown into folds; and, in fact, they resemble these rudimentary polypes in all points except in having no reproductive organs developed in connection with them.

6.—*Zoological Position and Affinities.*—

The position of *Virgularia* relatively to the other two genera is shown in the table on page 1 of this report. The generic characters, as stated by Kölliker,* are as follows:—

"Genus: *Virgularia.* Leaves small, attached to the rachis by wide bases, ending below in a long series of undeveloped leaves. Polype cells fused together along the greater part of their length, either in a single row, or else alternating so as to give the appearance of two rows. Tentacles cylindrical, with short pinnules. Reproductive organs, as a rule, contained within the rachis at its lower end, and only in a single species found in all the leaves. Zooids lateral, in single or multiple rows between each pair of leaves. Radial canals in two longitudinal ridges along the ventral side of the rachis. A terminal dilatation at the end of the stalk. Stems cylindrical. Calcareous spicules absent in the rachis, but present in some cases in the stalk in small numbers."

Of the nine species of this genus distinguished by Kölliker the descriptions of five are based on the examination of single specimens only; and of the remaining four there is no doubt whatever that the

* Kölliker, "Alcyonarien," p. 182-3.

one to which the Oban specimens are to be referred is the typical species of the genus, *V. mirabilis*, the definition of which is as follows:—

*V. mirabilis.** "Whole colony up to fourteen inches in length; feather two and a half to three times the length of the stalk; leaves half-moon shaped, smooth, placed laterally but slightly obliquely, the ventral border being higher than the dorsal, overlapping one another only slightly or not at all, attached by wide bases. Polypes six to nine in each leaf, their cavities distinctly separated from one another. Zooids lateral, in one or two rows. Reproductive organs only developed in the lowermost leaves. Radial canals well developed along the whole length of the rachis."

The species is a common but very variable one, different specimens differing greatly from one another in the pitch of the leaves—*i.e.*, their distance apart—in the shape of the leaves, and in their breadth of attachment to the rachis. In these points the seven Oban specimens present a good deal of variety among themselves.

7.—*Habits*—

1. *The Natural Position of Virgularia.* We have already, when speaking of *Funiculina* and *Pennatula*, referred in anticipation to *Virgularia* as affording positive proof of the erect position being the natural one. It is apparently a very simple point to determine; and yet, so far as we can find out, only two, or at most three, observers have recorded from actual observation the fact that *Virgularia* does live planted erect in the sea bottom.

Rumph † in his work, to which we have already alluded, describes both *V. Rumphii* and *V. juncea* as living erect with the stalk planted in the mud and the rachis projecting up into the water. He speaks of having pulled out hundreds, so that there can be no possibility of mistake.

Darwin, in his "Naturalist's Voyage Round the World," also gives us direct evidence on the point from observations made at Bahia Blanca, on the south-east coast of South America, in lat. 39° S. He says:‡—"I will only mention one other animal, a zoophyte (I believe *Virgularia Patagonica* §), a kind of sea-pen. It consists of a thin, straight, fleshy stem with alternate rows of polypi on each side, and surrounding an elastic stony axis, varying in length from eight inches to two feet. The stem at one extremity is truncate, but the other is terminated by a vermiform fleshy appendage. The stony axis which gives strength to the stem may be traced at this extremity into a mere vessel filled with granular matter. At low water hundreds of these zoophytes might be seen projecting like stubble, with the truncate end upwards, a few inches above the surface of the muddy sand. When

* Kölliker's "Alcyonarien," p. 190.
† Rumph. "T'Amboin 'sche Rariteitkamer," p. 64, 1741.
‡ Darwin: "Naturalist's Voyage round the World," p. 99, 1845.
§ Since renamed by Kölliker *Stylatula Darwinii* *Vide* "Kölliker: Alcyonarien, p. 227.

touched or pulled they suddenly drew themselves in with force, so as nearly or quite to disappear. By this action the highly elastic axis must be bent at the lower extremity, where it is naturally slightly curved; and I imagine it is by this elasticity alone that the zoophyte is enabled to rise again through the mud."

A little further on he says:—"It is always interesting to discover the foundation of the strange tales of the old voyagers, and I have no doubt but that the habits of the *Virgularia* explain one such case. Captain Lancaster, in his voyage in 1601, narrates that on the sea sands of the island of Sombrero in the East Indies he found a small twig growing up like a young tree, and on offering to pluck it up it shrinks down to the ground, and sinks unless held very hard. On being plucked up a great worm is found to be its root, and as the tree groweth in greatness so doth the worm diminish; and as soon as the worm is entirely turned into a tree it rooteth in the earth, and so becomes great. This transformation is one of the strangest wonders that I saw in all my travels; for if this tree is plucked up while young, and the leaves and bark stripped off, it becomes a hard stone when dry, much like white coral: thus is this worm twice transformed into different natures. Of these we gathered and brought home many."

These accounts are of great importance, as they prove beyond all possibility of doubt that the erect position is the normal one for *Virgularia*, and if so, it follows with almost absolute certainty that the same must be the case with other allied and similarly constituted genera.

2.—*On the Power of Retraction.*—This, also, is a point of very considerable interest and importance. It will be noticed that both Darwin himself and Captain Lancaster, in the accounts quoted above, state that *Virgularia* has the power of retracting suddenly into the sand when disturbed "so as nearly or quite to disappear." Rumph says exactly the same of *V. juncea*, which he describes as burying itself at low water so far in the sand that only a bit of three or four fingers' breadth projects.

We do not yet know whether *V. mirabilis* also possesses this power of retracting partially or completely into the mud when disturbed, but from analogy it would appear by no means improbable that it does so. The possession of this retractile power is clearly very advantageous for the sake of protection, and it will be an interesting point for future observation to determine whether this power is in any way a compensation for the loss of the more usual means of defence—*i.e.*, thread-cells. We have but little evidence on this point as yet. Rumph distinctly states that *V. juncea* does not sting, but does retract forcibly when disturbed: while *V. Rumphii*, which possess very marked stinging powers, is not mentioned as retracting.

Supposing, which seems probable, that *V. mirabilis* possesses this power of retracting partially into the mud, it would help to explain why the lower halves of the rachis escape, although the tops are so constantly eaten off.

Concerning the mechanism of retraction it is difficult to form any precise idea. From the descriptions it would appear to be a muscular action effected probably by the powerful muscular system of the stalk and rachis.

Some experiments made by Dalyell show well the efficiency of these muscles. He found that in living specimens the muscles of the rachis frequently cause the fleshy part to twist itself in a spiral manner round the stem, and then straighten out again. "A section, six or eight inches long, standing inclined in a narrow jar, will be found to have arranged itself in a single volute throughout, or into two, three, or four between night and morning. The whole can relax again into a straight line by their obliteration." *

Kölliker† suggests that the boring into the sand is effected by peristaltic waves of dilatation and contraction passing down the stalk and rachis: the dilated parts acting as fulcra by completely filling up the hole in which the stalk is planted, and so fixing it at one point, while the wave of contraction, passing down below this fixed point, would drive the end of the stalk deeper into the mud. The fixed point would then relax, the terminal vesicle would dilate to act as a fulcrum, and the longitudinal muscles would pull the whole colony down. It is, however, not easy to see how a rapid retraction could be effected in this manner.

3.—*Supposed Nocturnal Habits.*—According to Dalyell, *Virgularia* when in captivity "remains contracted during the greater part of the day, and the organs are seldom displayed before five or six in the afternoon." On this point we would refer to the observations made when considering the same statement concerning *Pennatula*. We have there suggested that *Pennatula* appears to be "nocturnal" when brought to the surface, simply because the amount of light it receives in broad daylight is vastly in excess of what it receives normally at the sea bottom, and that it is only towards evening that it is placed under what to it are normal conditions as to amount of light.

8.—*Geographical distribution.*

V. mirabilis has been taken at a number of localities in different parts of Europe. Like the Pennatulida generally it appears to be very local, but to occur in large numbers where it is found at all.

It has been recorded from several places on the coast of Norway and Denmark; from Belfast Lough, Gairloch, Oban, the island of Inchkeith, near to Edinburgh, the Hebrides, and other Scotch localities.

In 1879 the Birmingham Natural History Society added a new locality to the list by dredging a single specimen off Falmouth; and we may cite also, on Mr. Darbishire's authority, the stomachs of haddock off Scarborough, as a place where *Virgularia* has been found. The uncertainty whether these last specimens had been found by the

* Dalyell: *op. cit.*, p. 185. † Kolliker: *op. cit.*, p. 205.

haddock near where they were caught, or had been brought from some other locality, prevents our adding Scarborough definitely to the list until the point has been determined.

General Observations on Funiculina, Pennatula, and Virgularia.—

All three genera are colonial forms, consisting of a number of individual animals—the polypes—living organically connected together, and to a greater or less extent dependent on one another. In all three cases the colonies increase in size by the addition of new individuals by the process of budding or gemmation, whilst new colonies are started by means of eggs, which, when fertilised, give rise to free swimming embryos, capable of passing from place to place.

Of the three forms, *Funiculina* is the most primitive, and was therefore very properly taken first. Its more primitive nature is shown in the irregular arrangement of the polypes; in their independent insertion into the rachis; in the comparatively slight difference between the two kinds of individuals—polypes and zooids—comprising the colony, for these must be supposed to be primitively and fundamentally equivalent to one another; and also in the small length of stalk—*i.e.*, of the part of the colony devoid of polypes. A colony being merely an aggregation of similar individuals, which, instead of becoming detached and leading isolated and separate lives, remain organically connected together, it is clear that the simplest or most primitive form of colony will be that in which the polypes or individual animals are most completely independent of one another, and in which the differences between one polype and another are the least strongly marked, since all are fundamentally alike, and equivalent to one another.

Pennatula is in all these respects a far less primitive form than *Funiculina*. This is shown by the fusion of the polypes into leaves, clearly a secondary feature that could only have been acquired subsequently to the habit of forming colonies; by the very great difference in size between the component polypes of a leaf; by the great anatomical differences between the polypes and zooids; and by the great relative length of the stalk—*i.e.*, of the part of the colony devoted to purely colonial purposes.

Virgularia, though at first sight presenting a closer resemblance to *Funiculina* than does *Pennatula*, is in reality the most modified, the least primitive of the three genera, and has, therefore, very properly been considered last in this report. This is especially shown by the restriction of the reproductive organs to the imperfectly developed polypes, and the consequent division of the life-history of the polype into two physiologically and anatomically distinct portions—reproductive and nutritive. That the reproductive function should be thrown on the immature instead of the adult individuals is a very remarkable specialisation.

Again the modified character of *Virgularia* is shown by the great difference between polypes and zooids; by the simultaneous instead of the successive development of the polypes of each leaf, a point already explained; and lastly, by the development of the very remarkable system of vessels we have called radial vessels, which, whatever their function may ultimately prove to be, are structures not present in the other two genera, and the possession of which stamps *Virgularia* as a more highly specialised form than these.

In concluding our report, which various circumstances have combined to render much more lengthy than we had anticipated when commencing it, we desire to record our indebtedness to the members of the Birmingham Natural History Society for the opportunity they have afforded us of studying these rare and interesting forms; and for their liberality in placing the specimens at our disposal, and in enabling us to illustrate our report in a manner that cannot fail to greatly enhance its value.

We have been compelled to leave many points undetermined, but have in all such cases clearly indicated the nature of these points, and the difficulties by which we were baffled; and we have done this in the hope that we may thereby direct attention to the important work yet to be effected, and may facilitate in some measure the work of the Society in its future dredging excursions.

Description of the Figures in Plate I.

Figures 1 and 2 are reduced from full-sized drawings made by tracing the outline direct from the original objects. Figs. 4–9 are drawn direct with the camera from the objects themselves. Fig. 3 is constructed from separate camera drawings of the dorsal, ventral, and lateral surfaces; the four main canals, indicated by the dotted lines, are filled in from one of Kölliker's figures (*op. cit.* Pl. xvii., Fig. 151). The magnifying power is indicated in diameters for each figure. Figs. 1, 3, 4, 5, 7, 8, 9 are from the largest living specimen.

Alphabetical List of References.

a. Rachis.
b. Stalk.
c. Stem.
d. Polype.
e. Zooid.
f. Tentacle.
g. Calyx.
i. Spicule.
l. Cœnenchym, or fleshy body-substance.
u. Main canals of rachis.

Fig. 1.—Lateral view (right side) of the largest specimen, 39 ins. long, dredged living, shown in its supposed natural position with the stalk planted in the mud of the sea bottom, × 1-6th.

Fig. 2.—Similar view of perfect bare stem, 24ins. long × 1-3rd.

Fig. 3.—Transverse section of rachis at its widest part, showing zooids on dorsal surface, and polypes gradually increasing in size from the dorsal towards the ventral surface, leaving the aetual ventral surface bare; also the quadrangular stem, and the four main canals of the cœnenchym, × 3½.

Fig. 4.—Portion of dorsal surface of largest living specimen at the widest part of the rachis, about 6ins. from top, showing arrangement of zooids and polypes, × 2.

Fig. 5.—Ventral surface of the same portion, as in Fig. 4, × 2.

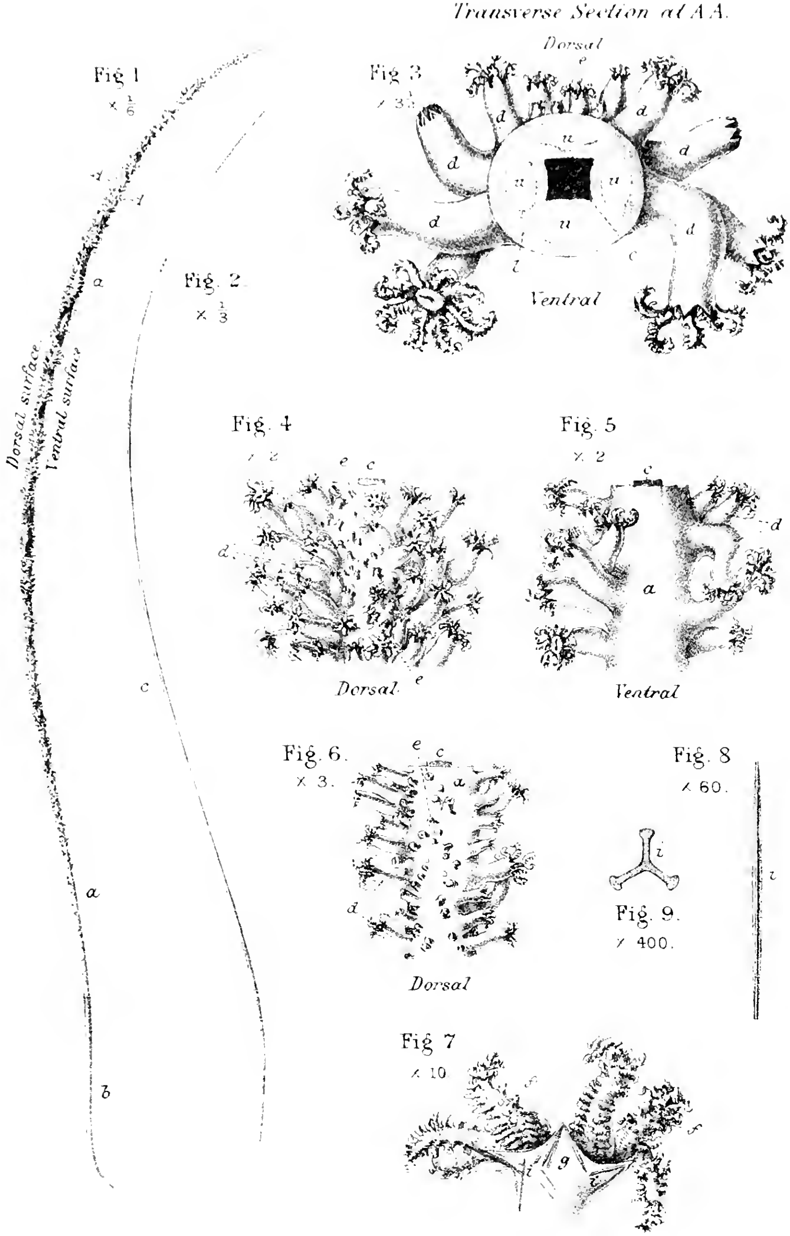
Fig. 6.—Portion of dorsal surface of younger specimen (20 ins. long) at widest part of rachis, showing arrangement of zooids and polypes, × 3.

Fig. 7.—Head of a polype, showing calcareous spicules in the calyx and its processes, × 10.

Fig. 8—.One of the calcareous spicules from the calyx, × 60.

Fig. 9.—Transverse section of calcareous spicule at the middle of its length × 400.

Plate I.



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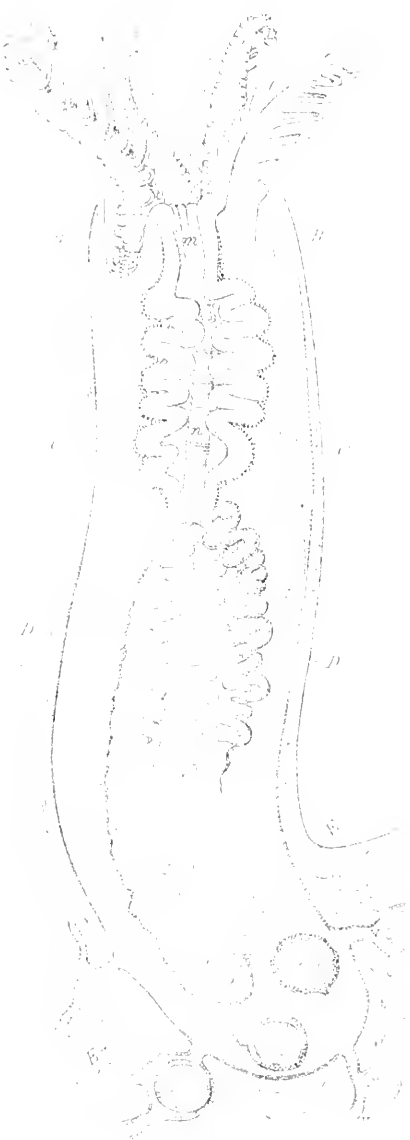
FUNICULINA QUADRANGULARIS

Plate II.

Fig 10

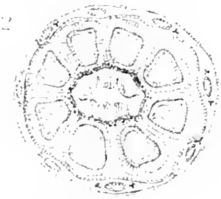


Section of Tentacle.

Fig 11

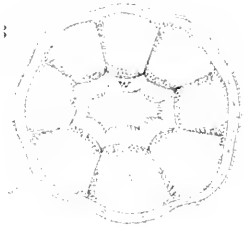
Transverse Section at B B

Fig 12



Transverse Section at C C

Fig 13



Transverse Section at D D.

Fig 14

Transverse Section at E E.

Fig 15

HYDRA QUADRANGULARIS

Description of the Figures in Plate II.

All the figures in this Plate are drawn from polypes taken from the largest living specimen. Fig 10 is constructed from a series of camera drawings taken from different specimens. Figs 11 to 15 are drawn with the camera from single sections. The magnifying power is indicated in diameters for each figure.

Alphabetical List of References.

f. Tentacle.
g. Calyx.
h. Cavity in calyx-process.
i. Spicule.
k. Body-wall.
l. Cœnenchym, or fleshy body-substance.
m. Mouth.
n. Stomach.
o. Mesentery.
p. Retractor muscle.
q. Protractor muscle.
r. Short mesenterial filament.
s. Long mesenterial filament.
t. Ovum.
v. Smaller canals of cœnenchym.
w. Ectoderm.
x. Mesoderm.
y. Endoderm.
z. Thread-cell or nematocyst.

Fig. 10.—A single polype, with the part of the rachis from which it springs, bisected longitudinally along its whole length; the plane of bisection adopted being the *plane of symmetry:* shows the whole structure of one of the polypes, and the communication of its body-cavity with the canal system of the rachis, × 22.

Fig. 11.—Transverse section through one of the tentacles at about the middle of its length; the section passing, on the right side, through the base of one of the pinnules. Shows structure of tentacle and pinnule and arrangement of thread-cells. × 70.

Fig. 12.—Transverse section through a polype at the line BB in Fig. 10; passing through the calyx, the bases of the tentacles, and the mouth. × 22.

Fig. 13.—Transverse section through a polype at the line CC in Fig. 10, showing the stomach and the mesenteries with their retractor muscles. × 22.

Fig. 14.—Transverse section through a polype at the line DD in Fig. 10, showing the mesenteries with the retractor muscles, and the long and short mesenterial filaments. × 22.

Fig. 15.—Transverse section through the lower part of a polype at the line EE in Fig. 10, showing the ova *in situ*, the long mesenterial filaments, and the openings of the cœnenchymal canals into the body-cavity of the polype.

Description of the Figures in Plate III.

Figures 1 and 2, representing the female specimen, are drawn directly from the object. Figs. 3-7 are taken from the male specimen; figs. 3, 6, and 7 being drawn direct with the camera from the original objects, while figs. 4 and 5 are constructed from separate camera drawings of the several parts shown. Fig. 8 is taken from one of the specimens from Naples.

Aphabetical List of References.

a. Rachis.
b. Stalk.
c. Stem.
d. Polype.
dl. Leaf.
e. Zooid.
f. Tentacle.
fo. Foreign body, swallowed as food.
g. Calyx.
h. Cavity in calyx process.
i. Spicule.
l. Cœnenchym, or fleshy body-substance.
m. Mouth.
n. Stomach.
o. Mesentery.
ov. Egg of Entomostracon embedded in mesenterial filament.
p. Retractor muscle.
q. Protractor muscle.
r. Short mesenterial filament.
s. Long mesenterial filament.
t. Ovum.
ts. Spermatosphere.
u. Main canals of rachis.
v. Smaller canals.
w. Ectoderm.
x. Mesoderm.
y. Endoderm.

Fig. 1.—Dorsal view of the female specimen. $\times \frac{5}{8}$.

Fig. 2.—Ventral view of the female specimen, showing zooids on ventral surface of rachis: also ova at bases of leaves. $\times \frac{5}{8}$.

Fig. 3.—Transverse section through the rachis of the male specimen, with the whole of the 13th left leaf, and the base of the 13th right leaf. Shows mode of formation of leaf by lateral fusion of polypes; also arrangement of zooids on rachis. On the right leaf the spicules are represented, but on the left they have been omitted for the sake of clearness. $\times$ 3.

Fig 4.—Longitudinal section of a single polype along the line AA in Fig. 3; the plane of section being the *plane of symmetry*, perpendicular to the flat surface of the leaf: shows whole structure of a polype. $\times$ 17.

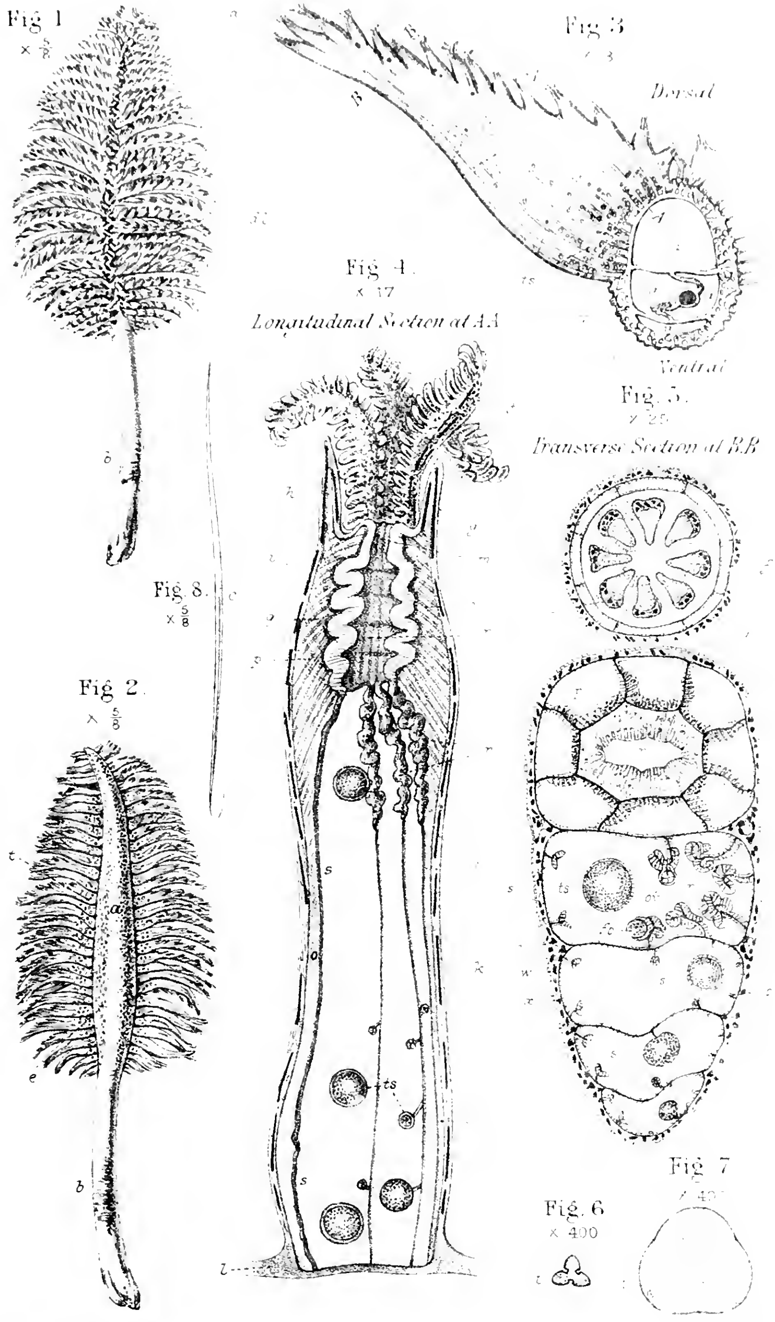
Fig. 5.—Transverse section through six contiguous polypes taken along the line BB in Fig. 3, cutting the several polypes at different portions of their lengths. The uppermost section passes through the calyx and base of the tentacles. The second section passes through the stomach, and shows the mesenteries and the arrangement of the retractor muscles. The third section passes through the mesenterial filaments below the stomach, and shows their division into two small and six large ones: shows also food particles in the act of being digested by the filaments, and a ripe spermatosphere. The fourth, fifth, and sixth sections are below the lower ends of the short mesenterial filaments; they show the long filaments, and the various stages of development of the male reproductive organs. $\times$ 25.

Fig. 6.—Transverse section through one of the smaller spicules. $\times$ 400.

Fig. 7.—Transverse section through a large spicule. $\times$ 400.

Fig. 8.—Separate view of bare stem. $\times \frac{5}{8}$.

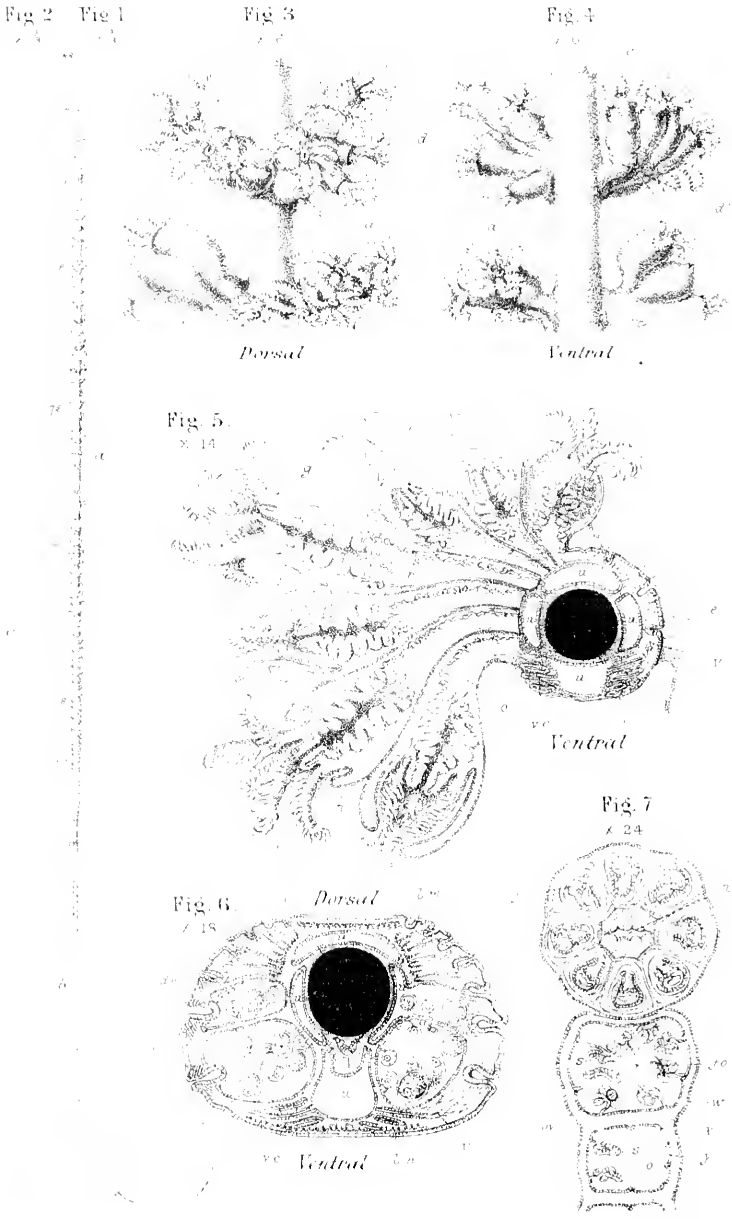
Plate III.



A M Marshall del.

PENNATULA PHOSPHOREA.

Plate IV.



VIRGULARIA MIRABILIS

Description of the Figures in Plate IV.

Fig. 1 is reduced from a drawing made from the specimen in the Glasgow Museum, referred to in the text as the only specimen at present known to be perfect at the top. The dotted outline of the stalk has been copied from a figure by Dalyell. Figs. 3 and 4 are drawn direct with the camera from one of the Oban specimens. Figs. 5, 6, and 7 are constructed from separate camera drawings of the several parts shown, the preparations in all cases being from one of the Oban specimens.

Alphabetical List of References.

a. Rachis.
b. Stalk.
c. Stem.
d. Polype.
dl. Leaf.
dr. Rudimentary polype.
e. Zooid.
f. Tentacle.
fo. Foreign body, swallowed as food.
g. Calyx.
h. Cavity in calyx.
lm. Longitudinal muscles of rachis.
m. Mouth.
n. Stomach.
o. Mesentery.
or. Egg of Entomostracon, embedded in mesenterial filament.
p. Retractor muscle.
r. Short mesenterial filament.
s. Long mesenterial filament.
t. Ovum.
u. Main canals of rachis.
v. Small canals of rachis.
vc. Radial canals.
w. Ectoderm.
x. Mesoderm.
y. Endoderm.

Fig. 1.—View of an entire specimen of *Virgularia*: the rachis drawn from the specimen in the Glasgow Museum, and the stalk copied from a figure by Dalyell. The figures along the left-hand side of the rachis indicate the pitch of the leaves at the points opposite which they are placed. Thus the top figure (48) indicates that at this point the leaves occur at the rate of 48 per inch. × $\frac{1}{3}$.

Fig. 2.—The stem of the specimen in Fig. 1, drawn partly from actual measurements, and the lower part added from figures by Dalyell, and Koren and Danielssen. × $\frac{1}{3}$.

Fig. 3.—Dorsal view of a small portion of the rachis of one of the Oban specimens, showing one pair of leaves and part of a second pair, with the rachis connecting them. Shows clearly the characteristic bending upwards of the ventral angles of the leaves. × 6.

Fig. 4.—Ventral view of the same specimen as in Fig. 3. Shows the bare ventral surface of the rachis; the mode of attachment of the leaves to the rachis; and the fusion of the polypes to form the leaves. × 6.

Fig. 5.—A transverse section of the rachis about its middle, with the whole of one leaf and the base of its fellow of the opposite side. Shows structure of rachis, with the stem, main canals, radial canals, and zooids; also the structure of the individual polypes, and their relations to one another and to the rachis. The most dorsal polype is represented entire; the others as if bisected horizontally. The several polypes are drawn in different degrees of expansion or retraction to show the alterations produced thereby in the arrangement of the parts, and especially in the calyx. × 14.

Fig. 6.—Transverse section through the lower end of the rachis, showing the stem, main canals, radial canals, rudimentary polypes; and the ova, both mature and developing. × 18.

Fig. 7.—A series of three transverse sections through different parts of polypes. The uppermost section passes through the base of the retracted tentacles, and through the œsophageal portion of the stomach. The middle section passes through the mesenterial filaments just below the stomach, and shows the arrangement of the filaments in a set of two long ones and a set of six short ones. The lower section passes through the body-cavity below the short mesenterial filaments; it shows the two long filaments and the six ridge-like mesenteries which bear higher up the short filaments. × 21.

GENERAL REPORT ON THE DREDGING OPERATIONS AT OBAN OF THE BIRMINGHAM NATURAL HISTORY AND MICROSCOPICAL SOCIETY, JULY 5TH TO 12TH, 1881.

BY JOHN F. GOODE AND WILLIAM P. MARSHALL.

Read before the Society, March 21st, 1882.

In this Dredging Excursion of the Society the operation of dredging was carried on from a small screw steam-yacht, the "Curlew," Capt. Adam, engaged for a week for this purpose, of about 20 tons burthen, 50ft. length, and 9ft. beam; speed about 10 miles an hour. From nine to twelve dredgings per day were obtained in depths of water varying from 15 to 53 fathoms, and most generally about 20 fathoms depth. This steamer was found to be smaller in size than was desirable for convenience of working, and for speed in getting out to the dredging ground.

The dredge-nets used were 2ft. wide and 2ft. long, with 10in. opening between the steel-edged scrapers at the mouth; a tangle, 16in. long, was attached to each bottom corner of the net. Three dredges were taken, two of them being generally in use alternately with one another. A length of 100 fathoms of 2½in. circumference rope was taken out, and the whole length was required for the deepest dredging taken, which was in 53 fathoms of water. One arm only of the dredge-frame was made fast to the rope, the other arm being attached to the rope by a lashing of small cord, calculated to break before any injurious strain could come upon the rope; and the utility of this provision was experienced on one occasion when the dredge got jammed fast at the bottom and the lashing parted, causing the dredge-frame to open, and the net to come up empty but safe.

When the dredge was hauled up the contents were emptied out for examination upon a working table 3ft. wide and 4½ft. long, covered with white oil-cloth, fastened down smooth. This was convenient for sorting out the specimens and washing off the mud that was brought up with them, and the end of the table projected over the side of the vessel for discharging the *debris* continuously direct into the water. Glazed iron pans, 16in. diameter and 3in. deep, were used in sorting and cleaning the specimens, which were then put into wide-mouthed glass jars of three sizes—6in. diameter by 16in. high, 3½in. by 8in., and 2in. by 6in. The glass jars were kept in a box divided into separate compartments for safe carriage, in which they were daily brought to and from the steamer, and were finally packed for conveying home the selected specimens transferred into spirit. Three galvanised iron sieves were also used, having 1½, ¾, and $\frac{3}{16}$ inch meshes respectively. Four tow-nets were taken, 1ft. diameter and 2ft. long, one made of coarse muslin, and the others of fine muslin; these were used occasionally, either from the steamer or from a rowing boat.

When the dredge was lowered it was left each time from ten to twenty minutes at the bottom, being either towed very slowly by the steamer, or allowed to drift with the current. The rope was hauled in by hand over the side of the vessel in raising the dredge; but a considerable inconvenience was experienced in doing this, from the labour of the work and the loss of time involved, about nine minutes being generally required for hauling in the dredge, even from the moderate depth of 22 fathoms. The provision of some simple hauling winch, with a leading pulley for the rope where passing over the side of the vessel (however rough in construction), will be an important advantage in future dredging operations; and these should be arranged so as to admit of being readily shifted in position, as the circumstances of the varying position of the dredge in the drifting of the vessel may render desirable.

A sketch map is appended, showing the localities of the several dredging stations; and an abstract is added of the log that was kept of the dredging operations, recording in each case the station, the time of lowering the dredge, and the time of remaining at the bottom, with a general note of the contents brought up, and the nature of the bottom.

The most important point of experience gained from the dredging is the great value of the *tangles* as a means of securing good specimens; the large Funiculina specimen was brought up by being caught by a few of the hempen fibres of a tangle, and was secured by this means in perfect and uninjured condition; and one of the two Pennatula specimens was also caught by a tangle. A serious defect, however, in the present tangles (which are attached one to each bottom corner of the dredge-net), is that the dredge *precedes* the tangles, and the heavy cutting edge at the mouth of the net consequently scrapes over the whole of the ground that is passed afterwards by the tangles, and is thus liable to break off and damage objects that are growing upright at the bottom of the water. An important illustration of this damage is given by the circumstance that all the Virgularia specimens (which have a very brittle and rigid stem) were broken off at the bottom, the point of fracture being at a quarter to three-quarters of an inch below the lower extremity of the "feather" or fleshy body, and most probably very near the surface of the ground in which the objects were growing.

In the report of the "Challenger" Dredging Expedition special value is assigned to the tangles, and as many as eight tangles were used together in the dredging, carried by a transverse bar 5ft. long at the bottom of the dredge-net, which was 4½ft. wide. A light iron rod was attached to each end of the tangle bar, extending to the mouth of the dredge, as a provision for keeping the dredge-net always extended to its full length, and for preventing any risk of the tangles or the end of the net getting folded over the mouth of the net, and so causing the dredge to come up empty. In the experience of the Oban dredging such accidents occasionally happened, and the adoption of a similar precaution in future is desirable.

Another point in which the working of the present dredge was not satisfactory is, that the dredge came up on several occasions only very imperfectly filled, and appeared to have not been dragged properly along the sea bottom, and to have been lifted off the bottom by the oblique pull of the rope. In the "Challenger" deep-sea dredging, where the difficulty from this cause was enormously increased by the dredging being carried to a depth of from 2½ to 4½ miles, a special contrivance was used for overcoming this difficulty, and a weight of 1½ cwt. was attached to the rope at 200 to 500 fathoms' distance in advance of the dredge (or a distance equal to about 1-8th of the depth being dredged). This "messenger" weight trailed along the sea bottom, and caused the pull upon the dredge to be under all circumstances in a direction parallel to the bottom and close down upon the ground, thus keeping the dredge at all times in the best position for its work. As a consequence of this arrangement, the risk was somewhat increased of the dredge getting jammed by some obstruction at the bottom, and whenever that occurred it became necessary to ease the rope by letting it slip for a certain distance, until the steamer could be backed over the dredge in order to clear it from the obstruction. The circumstance of the dredge becoming jammed was instantly ascertained by means of a spring-tension apparatus in the hauling tackle, the guiding pulley over which the rope was led to the dredge being suspended by a set of 80 strong india-rubber bands (similar to door springs), which were capable of stretching as much as 14ft. before reaching the strain at which the rope would break (2½ tons); and due warning was thus given by a sudden increased stretch taking place whenever the dredge got fast. In the Oban dredging this object was aimed at by feeling the tension of the rope by hand from time to time, to detect any undue resistance, and also to ascertain whether the resistance was sufficient for indicating that the dredge was dragging properly on the ground.

In order to prevent the injury of the specimens by the scraping lip of the net striking them before they can be caught by the tangles, it appears requisite for the tangles to be fixed separately farther up the rope in advance of the net, so that when the dredge is dragged along, the bottom shall be first *lightly swept* by the tangles before being *scraped* by the dredge; and it is also requisite that the cross-bar carrying the tangles shall not itself drag upon the ground so as to cause similar mischief to that previously done by the dredge scraper, but shall be propped up sufficiently high above the ground to prevent this, but not so high as to risk the tangles floating clear off the ground.

It is now suggested that the above objects, and also the other requirement of a "messenger" weight in advance of the dredge for ensuring a uniform horizontal pull upon the dredge, may be both conveniently effected by having a cross-bar carrying the tangles attached to the rope in advance of the dredge (say three fathoms in advance for twenty-four fathoms depth of dredging), and having a weight fixed to each end of this bar, of such a form as to drag upon the ground whilst holding up the bar at the required height above the ground;—the whole being made double-sided to provide for either side being uppermost when the dredge is lowered to the bottom. The present tangles at the bottom of the dredge-net to be retained as an additional provision, and the new tangle-bar to be made as much wider than the present dredge-net as may be practicable for convenient handling on deck.

In the "Challenger" Dredging it is worthy of note that the greater portion of the work was done with a wide *trawl-net* carried by a transverse beam that was as much as 18ft. in width with 20ft. length of net; and this was found so superior in results to the regular dredge-net of 4½ft. width and 4½ft. length, that the trawl-net was used for depths even as great as 3,000 fathoms, or 3½ miles. The two ends of the trawl-beam were carried about a foot clear above the surface of the ground by an iron-runner fixed to each end (like sledge-runners).

The trawl-net has an objection in the rather longer time required for sinking it to the bottom, and it is not so suitable for rocky or uneven ground as the narrow dredge; but it was used almost constantly during the latter part of the voyage of the "Challenger." In the deep-sea dredging (generally about three miles depth), the time required for lowering and hauling up the dredge was so great that only a single dredging operation could be effected in each day; the lowering of the dredge took about 3 hours, it was then allowed to remain at the bottom from 1½ to 2 hours, and 4 to 5 hours was taken for hauling up, the average rate of hauling up being 1ft. per second, or 10 fathoms per minute. The total number of dredgings effected in the 3¼ years that the "Challenger" voyage lasted was consequently not more than 504, these being nearly all deep-sea dredgings, extending to an extreme depth of 3,950 fathoms, or 4½ miles.

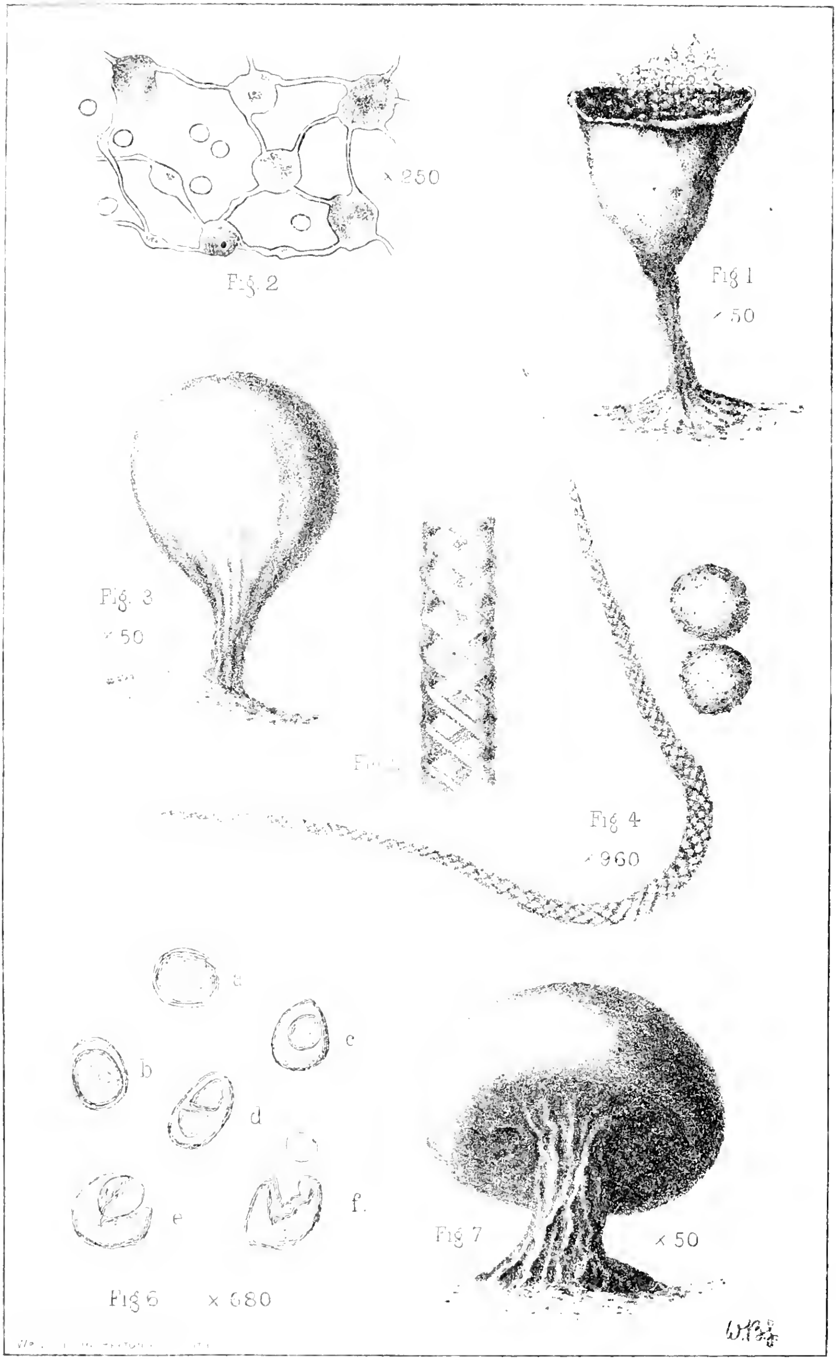
In future dredging excursions of the Society it appears also desirable to consider the employment of a small-sized dredge in addition to the ordinary dredge, and so small in size that it can be hauled in readily by a single hand, and can be quickly and conveniently used as a trial dredge without involving the delay and labour of lowering and raising the large dredge. Such a dredge, of only seven inches width, and requiring a rope only as large as a common lead pencil, has been very successfully used down to a depth as great as 60 fathoms by Mr. David Robertson, of Glasgow, in his important dredgings for Foraminifera on the coasts of Scotland and Norway.

In reference to the preserving of specimens, it is very desirable that on future occasions (as pointed out in the Report on the Pennatulida from Oban) some few specimens of each object—fragments will suffice—should be *preserved at once* in spirit directly they are captured, so as to be in good and natural histological condition for subsequent detailed examination with the microscope. The want of such preparations has been specially experienced in the microscopic examination of the Pennatulida specimens for determining difficult points of histological structure; the change of circumstances in the exposure of a deep-water object, even for a short time, to the higher temperature, diminished pressure, and greater light of surface water, being unfavourable to an accurate preservation of the microscopic details in animal structure.

ABSTRACT OF OBAN DREDGINGS—5TH TO 12TH JULY, 1881.

				I.	II.	III.	IV.	V.	VI.	VII.	VIII.
			Station	I.	II.	III.	IV.	V.	VI.	VII.	VIII.
			Depth in Fathoms	20	15	20-28	12-20	15-20	20	12	47-53
			Number of Dredgings	27	1	12	6	3	3	1	2
			Nature of Bottom	Shells, Stones, Mud.	Laminaria.	Mud.	Laminaria, Stones, Shells.	Laminaria, Stones.	Rock? Mud.	Stones, Shells.	Rock?
			Specimens Obtained.								
Porifera			Sponges	×	Barren, except for Laminaria.		×	×		×	Barren; possibly bottom was rock swept clean by current.
Cœlenterata	Actinozoa	Actinidæ	Sea Anemones	×		×					
		Caryophylleidæ	Corals	×							
		Pennatulidæ	Pennatula	×							
			Funiculina			×			×		
			Virgularia	×		×	×		×		
		Alcyonidæ	Dead Man's Finger	×							
Echinodermata	Crinoidea		Stone Lilies	×							
	Asteroidea		Star Fishes								
	Ophiuroidea		Brittle Stars	×		×	×				
	Echinoidea		Sea Urchins	×		×	×	218	×		
	Holothuroidea		Sea Cucumbers						×		
Vermes	Chætopoda		Sea Mouse, &c.	×		×	×				
	Polyzoa		Sea Mat	×		×					
	Brachiopoda		Lamp Shells	×			×		×		
Mollusca	Lamellibranchiata		Bivalves	×		×	×				
	Nudibranchiata		Sea Slugs	×		×	×				
Crustacea	Cirripedia		Barnacles, &c.	×		×					
	Malacostraca		Crabs, &c.	×			×	×			
Vertebrata	Tunicata		Sea Squirts	×		×	×		×		
	Pisces		Fishes	×		×	×				
			Locality of Stations	Off Dunollie and Maiden Isle.	Kerrera Sound, off Oban.	Half way from Oban to Lismore Point.	Kerrera Sound, southern end.	Dunstaffnage Bay.	Off Lismore Point.	Mid-channel, west of Lismore.	Loch Linnhe, north end of Lismore.

PLATE IIa.



THE MYXOMYCETES.

THE MYXOMYCETES.

BY W. B. GROVE, B.A.

Read before the Society January 24th, 1882.

The group of organisms named Myxomycetes,* or Myxogastres, constitutes a curious debatable land, concerning the nature of which the most diverse opinions have been and continue to be expressed. They form one of the groups which Haeckel united to form his new sub-kingdom—the Protista—which was intended to embrace all those simple forms of life in which the Animal and Vegetable Kingdoms approach one another. His object in instituting this arrangement was to get over the acknowledged difficulty of distinguishing between what of these are animals and what are plants. But, as Saville Kent lately,† and long before him Professor Huxley,‡ pointed out, he gets over the difficulty in a curious way. He proposes that, instead of having one line of demarcation to puzzle over, we shall in future have two, namely, that between undoubted animals and the Protista, and that between the Protista and undoubted plants. This, however, would not be an objection to his classification if it could be proved on other grounds to be desirable; for the question is not solely what course will be the easiest for us, but what will most truly represent the facts. Some of his proposed Protista, as the Diatoms, the Sponges, the Rhizopoda, the Noctilucæ, have now had their position definitively settled one way or the other. Others, such as Euglena, are still perhaps *sub judice*, and, since Saville Kent has made his recent and determined attack upon them,§ the Myxomycetes must now be considered to belong to the same doubtful category.

DESCRIPTION OF THE FIGURES IN PLATE IIA.

Fig. 1.—*Craterium pedunculatum*, Trent.
Fig. 2.—Capillitium and spores of the same
Fig. 3.—*Trichia fallax*, Pers.
Fig. 4.—Elater and spores of the same.
Fig. 5.—Diagram of portion of elater of the same, to show arrangement of spirals.
Fig. 6.—*a, b, c, e, f*, spores of *Physarum cinereum*, (Batsch.) dehiscing in water; *d*, less usual form, with the protoplasm divided into two masses.
Fig. 7.—*Didymium squamulosum*, (A. & S.), var. *costatum*.

All the figures are drawn from nature, except fig. 5, which is diagrammatic.

* *I.e.*, Slime-fungi.
† "Manual of the Infusoria," p. 44.
‡ "Quarterly Journal of Microscopical Science," 1868, p. 127.
§ "Manual of the Infusoria," pp. 41–3, 193, 170–2; and "Popular Science Review," April, 1881.

On inquiry into the facts known concerning this group, it will be apparent that the settlement of the question is by no means easy when all things are taken into consideration. There are, of course, three possible conclusions open to us: We may decide that the Myxomycetes are animals; or that they are plants; or that they are the former at one period of their existence, and the latter at another. The last-named possibility, however strange it may appear, must not be overlooked, since it is evident that the belief in the fundamental distinction of the two classes of living things, founded, as it was originally, upon an acquaintance only with the higher forms, has of late years received many a rude and, it may be, fatal shock. It is easy to denounce such a conclusion as the refuge of timidity; it is another thing to prove that the dividing line in Nature is really an impassable one. The mycologists of this country have long made up their minds in favour of the truly vegetable nature of the group, and most of them would be sorry to lose a class of Fungi in which some of the most remarkable and beautiful species are to be found. But at the same time it is quite certain that the particular position formerly assigned to them among the Fungi is no longer tenable, being founded upon a gross disregard of many of their characteristics.

There is one point which it seems to be essential to consider, but which, so far as I have read, has not been introduced into the controversy. If we believe that all animals and plants are genetically connected, that is, are all descended alike from one or more primordial forms of life, we should anticipate not only that there would be a point of contact between the two living kingdoms of Nature, but that there would be several such, and these, perhaps, occurring at parts of our classification far removed from one another. Botanists know that no large group of plants can be arranged in a linear series so as to display fully their mutual affinities. The species of a large genus, or the genera of a large order, require to be grouped on a plane, or it may be even in space of three dimensions, in order to show how they are connected with one another. It is of course understood that in a perfect arrangement the points of junction would really indicate genetic descent. In the same degree, then, at least, or more probably in a greater, ought we to find many points of junction between animal and vegetable forms. While the Fungi merge insensibly in the Algæ, and the Algæ in the Protozoa, yet there may be a point where the Fungi are connected with the Protozoa immediately, and that is through this group of Fungi, the Myxomycetes.

OUTLINE OF THE CONTROVERSY.

It will be well to give a short outline of the opinions about the Myxomycetes before proceeding to describe them. Up to and including the year 1857, when Rev. M. J. Berkeley published his "Introduction to Cryptogamic Botany," the Myxogastres, as they were then called, were placed among the Gastromycetes, their nearest allies being the Trichogastres or Puffballs. At this time nothing was known of their development. In 1859 Dr. de Bary, Professor of Botany at the University of Freiberg, for the first time observed the germination of the spores, and found that, instead of giving rise to a jointed hypha or filament, as other Fungi do, they produced an actively locomotive creature resembling a monad. After examining a number of the Myxogastres, and finding the germination of the spores the same in all, he considered that he had grounds for the opinion that these organisms had more affinity with the Protozoa than with Fungi, and proposed for them the name Mycetozoa.* These results were independently confirmed by a Polish observer, Cienkowski, and armed with this confirmation, de Bary published, in 1864, a larger work, in which he repeated his belief in the animal nature of these creatures.† About 1868, Haeckel proposed his idea of including these, as well as other doubtful forms, in a distinct group, the Protista. In 1871 appeared Cooke's "Hand-book of British Fungi," which is merely, as far as concerns the larger divisions, a reprint of Berkeley's classification, which is itself taken mainly from the great Swedish Botanist, Fries. The Myxomycetes are consequently there placed among the Gastromycetes, and this position has since been retained for the additional species recorded in "Grevillea" up to the present time. In 1875, another Pole, Rostafinski, issued a Monograph of the Mycetozoa, in which he appears, though not very clearly, to incline to the animal side of the controversy. This is still the standard work on this group of Fungi, and it is curious that the ambiguous definition there given is invoked equally by each party to the controversy as favouring his particular view.

In 1875 also the English edition of "Sachs' Botany" was published, in which the Myxomycetes, as they are there called, were placed as a supplement or appendix to the Fungi. In the same year appeared the fourth German edition of Sachs', in which a change was made in the classification. The Algæ and Fungi are there arranged in two parallel series, distinguished from one another solely in the fact that one series produces chlorophyll and the other not. The Bacteria are placed, as the lowest Fungi, on a level with the unicellular Algæ, and next (passing over the small group of Saccharomycetes) we have the Myxomycetes, paralleled in the other column by the Volvocineæ among the Algæ. Professor Allman, in his Presidential Address to the British Association in 1879, declares that, "though the affinities of the Myxomycetes with the Fungi are, perhaps, closer than with any other plants, they differ from them in so many points, especially in their development, as to render this association untenable." ‡

Saville Kent, in his "Manual of the Infusoria," and more recently in the "Popular Science Review," adopts the animal hypothesis, and offers many new facts and parallels from the Animal Kingdom in support of his belief. To this, at present, no reply

* *I.e.*, Fungus-animals.
† This belief he has now changed; "he holds and teaches that they are veritable plants."
‡ British Association Report, 1879, p. 14.

has been given, except to tell Saville Kent that he "has gone out of the way to meddle with a subject which he does not understand." It is evident that a wider and deeper knowledge of the facts concerning not only the Fungi, but the Protozoa, is needed, before the problem can be completely settled. One writer has even suggested lately "the abolition of the group, and the placing of their principal divisions in the various orders of Fungi to which their fructification presents the closest resemblance."* This method of treating them would be similar to that which has been adopted so successfully by modern cryptogamists with regard to the group of Mosses formerly named Phasceæ, though in that case leaf-structure formed the basis of the distribution.

DESCRIPTION OF A MYXOMYCETE.

The following is a brief account of a fully-developed Myxomycete. It consists mainly of a spore-case or sporangium, which assumes one or other of two distinct forms: first, it may be definite in shape, spherical, hemispherical, ovoid, lenticular or reniform, stalked or sessile; or, second, it may be without a very definite outline, forming merely an extended cake-like or reticulated mass, which takes its shape for the most part from the accidents of its position. The sporangia vary in size, from a little rounded heap just visible to the naked eye, to a mass two feet long and an inch or more thick. This sporangium may have one or more walls, either of which may contain a deposit of lime—usually, it is said, in the form of oxalate—either in thinly-scattered crystals or granules, or forming the greater portion of its substance. The walls of the sporangium and the stem are destitute of proper cells: they are often composed of a delicate homogeneous membrane, or only bear a few thickenings on the surface in certain forms peculiar to the different species. The stem often springs from a small patch of a similar homogeneous substance, called the hypothallus, by which it is attached to the matrix.

The contents of the sporangium most often consist of a vast number, sometimes millions of millions,† of spores, amongst which there is present, in addition, a structure called the capillitium; in a few cases the capillitium is apparently wanting. The capillitium is composed of threads, sometimes simple, sometimes branched; sometimes free, sometimes combined; in one species formed of delicate tubes with translucent walls, in another furnished with spiral markings or ridges or spines projecting from their outer surface; sometimes containing air, and at other times filled with lime. In many cases, also, the knots or points of junction of the threads are enlarged, and these knots may, or may not, contain lime. The mode of attachment of the capillitium is also extremely varied. In Trichia the threads are perfectly free at

* Van Tieghem, "Bull. Soc. Bot. France," xxvii., p. 322.

† I have calculated, from measurements, the number of spores in one sporangium of *Comatricha typhina*; there were at least one hundred millions. The number in an æthalium of Reticularia or Fuligo must be enormously greater.

both ends. In Prototrichia and Enerthenema they are attached to the sporangium at one end only. In Didymium and allied genera they are arranged radially. But in the majority of the species they form a more or less complicated network, in which a few of the ends may be free, while most of them are attached to the wall of the sporangium. In Stemonitis and Comatricha the stem penetrates the sporangium, forming an axis, called the columella; in other species the columella is the swollen summit of the stem, or merely a denser portion of the capillitium; in some it is altogether absent. The spores in all cases densely fill up the interstices of the capillitium. When mature the sporangium dehisces either irregularly, as in Trichia, or radially, forming segments which curl back like those of a Geaster, or the petals of a flower, as in some species of Chondrioderma, or longitudinally, as in *Physarum sinuosum*. In Craterium a distinct lid or operculum is formed, and in Perichæna the wall of the sporangium splits in a circumscissile manner, like the capsule of the Henbane or Field Pimpernel. Oftentimes the upper portion of the wall of the sporangium splits off in minute fragments, and the capillitium is left exposed, and in the case of Arcyria its elasticity causes it to enlarge to several times its original size. The spiral threads of Trichia twist about like the elaters of the Hepaticæ under the influence of alternations of heat and moisture. In these various ways the spores are dispersed.

The spores are spherical, usually with a smooth, but frequently with a ribbed or spiny coat. They fall into two groups as regards colour: in one group the spores are dull-coloured, either brown or brownish-violet, almost black; in the other they are of a bright colour, such as yellow, ochreous, red, purple, or pink. In this, as in many of the lower plants, we find colour, which, in the higher groups, is so untrustworthy, furnishing one of the primary bases of classification. In a few genera, as Badhamia, the spores are at first collected in groups, surrounded, according to Berkeley, by a hyaline sac; but the existence of this envelope is doubtful.

DEVELOPMENT OF A SPORE.

Let us now trace the development of the spore of a typical Myxomycete. When one of these is placed in suitable conditions, as in water, it dehisces, and its contents pass out as a transparent, colourless sphere of protoplasm, possessing sometimes a nucleus and a contractile vacuole.* This remains for a time motionless, but soon we can perceive little undulations of its contour, which gradually increase in extent until the shape becomes elongate, and then suddenly there is developed at the end next the nucleus a long flagellum, which flickers gently at first, then more rapidly, and at last attains power enough to move the body from its position. The object then resembles an ordinary free-swimming flagellate monad. After swimming about for a few hours or days it sinks to the bottom of the water, and there

* See Plate III., Fig. 6.

creeps about by throwing out pseudopodia, while it still retains its flagellum, and in this state it resembles the Infusoria known as Mastigamœba and Reptomonas. The flagellum is then absorbed, and the creature becomes extremely similar to an ordinary amœba. Both in this stage and the preceding it increases by fission, and takes in solid particles of matter, and apparently extracts the nutriment from them just as an amœba does. This point seems to be set at rest by the very definite observations that have been made, and is acknowledged by Sachs, who places the Myxomycetes among the Fungi, as much as by Saville Kent, who claims them for the Protozoa, although some mycologists appear to regard the statement as incorrect.* De Bary and Cienkowski both witnessed the ingestion of solid food. Saville Kent fed his specimens upon carmine, and after a time found the solid particles embedded in the protoplasm, just as we find diatoms in an ordinary amœba.

It may be as well to pause here for a while to point out the significance of these facts. The capacity of taking in solid food is usually considered the prerogative of animals; plants imbibe their food in a liquid condition; and Saville Kent, who insists that the statement in this naked form furnishes a distinct line of demarcation between the Animal and Vegetable Kingdoms, considers that this one point, well established, decides the question. But if we consider the difference more deeply, I do not see that it affects the controversy in any way. Why do plants usually imbibe their food in a liquid form? Because the protoplasm of plants has the habit of surrounding itself with a wall of cellulose, in which are no pores capable of admitting solid particles of even microscopically visible size. Animals on the contrary have a mouth, by which they can take in particles of various sizes according to the capacity of the opening, or else, as in the Rhizopoda, their protoplasm is not surrounded by an impermeable wall. In either case, however, the nutriment is reduced to a liquid form, by digestion, before it actually enters and becomes a part of the substance of the body.

If, then, we should meet with a plant in which the protoplasm was naked, we should expect it to possess also the power of ingesting solid food. It need not be said that naked protoplasm is met with in the Vegetable Kingdom, as in all kinds of spermatozoa or antherozoids, and the zoospores of Algæ, and you will remember the curious observations of Francis Darwin upon the protrusion of naked protoplasmic filaments from certain glands on the leaves of the Teasel, and also from the cells of the stem of *Agaricus muscarius*.† The real difficulty is to explain why these fungi do not develop cellulose coats to their protoplasm, not to account for their taking in solid food. The flagellum, too, is nothing more than a minute thread of protoplasm projected from the body, and is possessed alike by the gonidia of Volvox, and most zoospores and antherozoids.

* Grevillea, ix., 43.
† "Quarterly Journal of Microscopical Science," 1878, pp. 74-82.

Again, the possession of a contractile vesicle is urged as a proof that these creatures cannot be plants. Saville Kent says that, according to his observations, a rhythmically pulsating vesicle is possessed by none but members of the Animal Kingdom. But here there is a great temptation to reason in a circle; first, to make the possession of a contractile vesicle the criterion of animality, and then to declare that none except animals possess one. There are, no doubt, a few difficulties in the way. Our esteemed member, Mr. Wills, quotes, though without actually approving it, the statement of Busk, that the gonidia of Volvox, when young, possess one or more contractile vesicles. Saville Kent tries to explain the origin of the statement by the supposition that Uroglena was mistaken for Volvox. But the zoospores of Peronospora, of Cystopus, of some Saprolegnieæ, of Ulothrix, of Chætophora, of some Palmellaceæ, of *Microspora floccosa*, and of *Stigeoclonium tenue*, etc., have also been observed to be furnished with contractile vacuoles.*

Lastly, it may be objected that the power of amœboid movement is characteristic of animal organisms. But, here again, the Volvocineæ come to our aid. Archer, in 1862, observed the primordial cells of Stephanosphæra (an Alga allied to Volvox) leave the hyaline sphere in which they are usually contained, and move about the field exactly in the manner of a green Amœba.† In fact, although they moved, like Amœba, by extensions and retractions of pseudopodia, they went so fast that they might have given even *Lithamœba discus* fifty micro-millimeters start out of a hundred, and yet have won the race. Various other cases of the same kind are recorded among mosses, algæ, fungi, etc.,‡ and Sachs instances the amœba-like movement of the protoplasm which escapes from a ruptured cell of Vaucheria, as similar in its character§.

We left our Myxomycete in an amœboid form, creeping over the matrix upon which it grew, increasing by fission, and feeding perhaps upon the bacteria and other organised substances in the fluid. In this state it has received the name of Myxamœba. Where one spore has germinated there will probably be many more, and these, creeping about, meet and unite with one another in gradually increasing numbers, and at last form a mass, technically known as a plasmodium, which is relatively of colossal size, and which creeps about in a reticulate manner over the matrix. It sends out pseudopodia in various directions, and retracts them again, just like a gigantic amœba or some species of Foraminifera.

Moreover, this plasmodium consists of an outer denser transparent layer not containing granules, and an inner granular mass in which

* Huxley, "Science and Culture," pp. 164, 170, and "Comptes Rendus," June 16, 1879.

† "Quarterly Journal of Microscopical Science," 1865, pp. 116, 185.

‡ "Quarterly Journal of Microscopical Science," 1862, pp. 96–103.

§ Sachs' Botany, p. 41.

‖ I have seen a plasmodium of *Physarum cinereum*, forming a patch of jelly-like substance nearly as large as one's hand, which roamed about the surface of a rotten stump for three weeks, and finally retreating to the base formed its sporangia in a few hours. In a day or two the sporangia were ripe and dehisced, and in a week nothing was left but their bleached and empty bases.

are embedded a number of contractile vesicles derived from the units of which the mass was formed. The plasmodium is continually moving while the conditions are favourable: those of the larger species can creep some distance and ascend bushes and plants. A distinct circulation or cyclosis can be observed in the contents, a streaming motion of the protoplasm, like that of Nitella, but more resembling the motion of the reticulated protoplasm of the Foraminifera, as in Gromia and Labyrinthula.

Should the conditions become unfavourable, this plasmodium will pass into an encysted or resting stage, but if they continue suitable, the net-work begins to contract and to put forth outgrowths upwards of the form of the future sporangia. It then forms a firm membrane on the outside, usually without any trace of structure, while the enclosed mass proceeds to resolve itself into spores by free cell formation. If the sporangium is to contain threads, part of the protoplasm collects into stringy filaments. The lime is crystallised out, either in the wall of the sporangium or in the capillitium, or in both, and the water is expelled or evaporates. This process takes place very quickly, and thus the cycle of development is completed.

In a few instances, as in Enerthenema and Ophiotheca, the spores are described as being attached to the threads, but it is probable that this is a mistake, and that the spores are really always free, being formed like those of the Ascomycetes. Certainly I could find no trace of their attachment in any specimen of Enerthenema which I have examined.* It will be seen that, in this formation of the spores by endogenous division, the Myxomycetes differ essentially from the Trichogastres and the Nidulariacei, between which they are placed in Berkeley's classification, as well as from the other Gastromycetes, in which the spores are always borne upon sporophores, just as in the higher group.

It is but just to say that the foregoing account of the germination of the spores is not uncontradicted. Both Berkeley and Currey † mention having observed the spore of a Myxomycete germinate in the ordinary way by the emission of a hyphal filament; but we may more easily suppose that in these cases the spore of some extraneous species was accidentally present than that all other observers are wrong, or that both methods of germination are possible. Van Tieghem has recently described a modification of the process related above, where the myxamœbæ, instead of forming a plasmodium in which the units of which it is composed are undistinguishable, remain completely independent though aggregated together, each forming itself into a single spore with a cellulose coat.‡

* Dr. Quelet has recently asserted that the spores of all species are borne on the threads as sporophores, apparently on his own authority. But then he also calls the plasmodium by the totally inappropriate name of mycelium—"J. de Photo. et de Micro.," 1881, translated in "Northern Microscopist," March, 1882.

† "Transactions of the Linnæan Society," xxiv., p. 156.

‡ Van Tieghem, "Bull. Soc. Bot. France," xxvii., pp. 317—22.

AFFINITIES OF THE MYXOMYCETES.

We are now prepared to consider what the affinities of the Myxomycetes are, and it becomes at once apparent that the question, so far from being capable of settlement off-hand, as some would treat it, is really very complex; for the analogies which we can perceive between these organisms and other members of the animal and vegetable world are very numerous and far-reaching. It becomes a question, then, which analogies indicate affinity, and which are merely those apparently accidental resemblances which occur throughout every department of Nature.

The sporangia bear a considerable likeness to those of some Gastromycetous Fungi, especially in the fact that the interior, when mature, is filled with a dusty mass of threads and spores, but as already mentioned the origin of the spores is quite different in the two cases. The sporangia resemble also more remotely the capsules of Mosses and Hepaticæ, while the spiral threads which are mixed with the spores of Trichia remind us of the elaters of the Jungermannieæ; but from these they differ in the fact that the elaters are cells, with a separable spiral coiled within, while the Trichia threads, even if it be granted that they are cells, contain no spiral, the appearance being an optical effect produced merely by a rounded spirally-arranged elevation of the outer wall.* The spores also outwardly are like the spores of many other Fungi, but the development of the spore is *sui generis*, and its contents, as soon as they have developed their flagellum, resemble common free-swimming monads, and in their creeping stage, first, the infusorian Mastigamœba, and, secondly, the rhizopod Amœba. Again, we can compare the huge plasmodium formed by their union with the ramifications of the protruded protoplasm of the Foraminifera, in which also the same cyclosis or slow circulation of the contents is observed. It may also be compared, according to Saville Kent, to the homogeneous sarcode which forms the basis of sponge structure, which in the same way is composed, if our authority be correct, by the amalgamation of a vast number of amœbiform units. Moreover, the substance of the threads which occur with the spores, according to the same author, bears some likeness to that of the keratose or horny fibres of the order of Sponges called *Ceratina*, while still more strangely the calcareous deposits in many species simulate those of the order of Sponges called *Calcarea*, and in a few, he says, even assume a regular six-rayed form, reminding one irresistibly of a sponge spicule. But in these respects the author's enthusiasm seem to have outrun his judgment; the threads of the Myxomycetes are not of a very horny nature, nor are the crystals by any means so regular as he would imply.

But, even allowing these resemblances, and that the Sponges belong to the Protozoa, can we find anything in the Protozoa at all

* "Quarterly Journal of Microscopical Science," 1855, pp. 15-21. But the opposite opinion has been maintained; "Transactions of the Linnæan Society," xxi., pp. 221-3, where, however, the figure contradicts the text.

comparable to the last spore-bearing stage of the Myxomycetes? Saville Kent answers in the affirmative, and compares it with the encystment of species of Monas and Heteromita, such as has been revealed by the labours of Messrs. Dallinger and Drysdale, a process similar to which, according to Saville Kent's own observations, is very prevalent among the Protozoa, although unknown a few years ago. The chief difference is one of degree, the sporangium in the Myxomycete being formed by the union of a vast number of amœbiform units, and in the Protozoan usually by the combination of a few only. But this difference is bridged over by those species with aggregated plasmodium, described by M. Van Tieghem (supposing them to belong really to the Myxomycetes), where the sporangium is formed at times by a small number of myxamœbæ only.*

The only real distinction† between the Animal and the Vegetable Kingdoms (if there be one at all) is founded upon their physiology. Plants possess the power of building up organised substances out of dead matter; animals require ready organised material for their food. Fungi, indeed, resemble animals in this respect, that they usually live upon the nutriment already elaborated for them in vegetable cells, but that they do possess the characteristic power of plants every yeast cell thriving in Pasteur's solution is a living witness. The Myxomycetes ingest solid particles within their protoplasm, but the quantity of nutriment thus obtained must be very small, and the huge masses, which are sometimes so quickly formed and in such unlikely places,‡ must depend for their growth chiefly upon inorganic material obtained from the water and the air surrounding them. They are, therefore, plants. But it may be urged that, if so, many monads must be plants also. This may be a "logical consequence," but logical consequences have no terror for the seeker after truth. In the discussion of these questions there is no room for prejudices or personalities; the mind must calmly weigh the evidence, and judge without fear as without favour.

Reviewing then the whole question, we decide at once that the position assigned to the Myxogastres by Fries is quite untenable. In fact, nearly the whole of Berkeley's main classification (adopted in the Handbook) is now out of date, and does not represent the present state of knowledge about the Fungi. Its chief recommendation is that it is easy to understand and apply, but it is in many respects nearly as artificial as was the system of Linnæus in the Phanerogams.

Saville Kent's contention also, that these organisms belong to the Protozoa, is as untenable. He lays the whole stress of his argument upon their mode of development, but it is usually allowed that the true position of any organism is determined by the affinities of its

* Van Tieghem, "Bull. Soc. Bot. France," xxvii. pp. 317-22.
† Huxley's "Science and Culture," p. 162.
‡ The Myxomycetes are found usually on rotten wood or other decaying substances, but they seem to be indifferent as to the matrix on which they grow. One species was found on iron which had been heated only a few hours before, another on a leaden tank, another on cinders. See Berkeley's "Introduction to Cryptogamic Botany," p. 340.

adult condition. He says, that "with those mycologists to whom every spore-capsule is necessarily a fungus, and whose vision is sealed to every organism beyond their special line of research, the Mycetozoa will to the end of time be Fungi still," and although it is to be feared that few mycologists will recognise themselves in that very comprehensive definition as those "to whom every spore-capsule is necessarily a fungus," yet they do for the present believe that they are "Fungi still." But they must place them in a position like that assigned to them in the fourth (German) edition of Sachs' Botany, where they are considered as one of the lowest and most aberrant groups of Fungi, forming equally with the lower Algæ a point of approach to the Protozoa.

FIRST LIST OF THE MYXOMYCETES OF THE NEIGHBOURHOOD OF BIRMINGHAM.

The species are arranged according to the method of Rostafinski, with the synonyms of the "Handbook" added.

1.—*Physarum cinereum* (Batsch.), *Didymium cinereum*, Fr. Sutton, on a decayed, polyporus-covered stump. (See page 92.) Feb.

2.—*P. sinuosum* (Bull.), *Angioridium sinuosum*, Grev. Sutton park, on a dead holly leaf. Sep.

3.—*Craterium vulgare*, Ditm., *C. pedunculatum*, Trent. Sutton Park and Olton Reservoir, on dead bramble twigs. Oct.

4.—*C. leucocephalum* (Pers.) Sutton, on dead bark. Jan.

5.—*Tilmadoche nutans* (Pers.), *Physarum nutans*, Pers. Sutton and in Sutton Park, on dead bark Oct., Nov.

6.—*Leocarpus fragilis* (Dicks.), *Diderma vernicosum*, Pers. Sutton Park, on leaves of grass and stems and leaves of bilberry. Sep.

7.—*Didymium squamulosum* (A. and S.), var. *costatum*. Oscott, on dead bark. Jan.

8.—*Chondrioderma difforme* (Pers.), *Diderma cyanescens*, Fr. Sutton and Sutton Park, on dead bark. Oct., Nov.

9.—*Spumaria alba* (Bull.) Sutton, on petioles of coltsfoot. Sep., Oct.

10.—*Stemonitis fusca* (Roth.) Sutton, on dead wood. Sep.

11.—*Comatricha Friesiana* (D. By.), *Stemonitis obtusata*, Fr. Sutton, on dead wood and decayed polyporus. Oct.—Jan.

12.—*Enerthenema papillata* (Pers.), *E. elegans*, Bowman, *not* Cooke. Sutton, on rotting wood. Feb.

13.—*Reticularia lycoperdon* (Bull.), *R. umbrina*. Fr. Sutton and Oscott, on logs. Oct., Nov.

14.—*Trichia fallax*, Pers. Sutton, on rotten wood. Oct.—Jan.

15.—*T. varia*, Pers. Sutton, on rotten wood. Aug.—Nov.

16.—*T. varia* (Pers.), var. *nigripes*, *T. nigripes*, Pers. Oscott and Sutton, on rotten wood or bark. Nov.—Jan.

17.—*Prototrichia flagellifera* (B. and Br.), *Trichia* (?) *flagellifer*, B. and Br. Sutton, on rotten wood or bark. Sep., Feb.

18.—*Hemiarcyria rubiformis* (Pers.), *Trichia rubiformis*, Pers. Sutton, on rotten wood. Sep., Oct.

19.—*Arcyria punicea*, Pers. Sutton, on rotten wood. Aug.—Oct.

20.—*A. cinerea* (Bull.), *A. cinerea*, Schum. Sutton, on decorticated branches. Nov.

21.—*A. incarnata*, Pers. Sutton, on rotten wood. Oct., Nov.

22.—*Perichæna corticalis* (Batsch), *P. populina*, Fr. Sutton and Sutton Park, on the inner side of dead bark, often covering a large area. Sep.—Nov.

NOTES ON BEAVERS AND THE BUTE BEAVERY.

BY EGBERT DE HAMEL.

Read before the Society, February 14th, 1882.

Amongst the Mammalia is a most interesting group of animals, many species of which exist or have existed in Great Britain, whose domestic economy is to a large extent unobserved owing to their extreme timidity and consequent shy and nocturnal habits, albeit their names are for the most part familiar to us. I refer to the order Rodentia, or gnawing animals, which includes the various genera of rat, mouse, squirrel, hare, rabbit, porcupine, capybara, guinea-pig, and the subject of my present paper, the beaver.

The chief characteristics of this order are the incisor teeth in the centre of each jaw, the absence of canine teeth, and the wide space between the incisor and molar teeth, an arrangement admirably qualifying them for gnawing solid substances, to which end the incisors are enamelled only on the front surface, so that the back part being softer is by gnawing worn away fastest, and the cutting edge kept sharp. To remedy the loss of substance a constant growth takes place from the root; they are, moreover, semicircular in form, three-fourths of which being buried in the jaw adds enormously to their power. The molar teeth are broad and calculated for masticating vegetable food; the articulation of the lower jaw works in a longitudinal groove in the skull, affording great facilities for grinding their food: the feet are furnished with toes and nails, and are more or less webbed; the fore paws are remarkably handlike, the hind legs much the longest.

I shall now confine my observations to the "species" Beaver, and endeavour, first, to point out to you such of its life-history as I have been able to gather from the many writers on the subject, following these particulars with a description of what I witnessed on the occasion of a special visit paid to the Marquis of Bute's beavery at Mount Stuart, near Rothesay, in the island of Bute, at the latter end of August, 1878.

The earliest notice we have of the beaver occurs during the 9th century, where we find that whilst an otter's skin was only worth twelve pence, that of the Llosdlydan or beaver was valued at one hundred and twenty pence.

This animal was not uncommon in the rivers of Wales towards the close of the 12th century. Giraldus Cambrensis informs us that the species became extinct in 1188, but according to some historians it was a native of Scotland and England until the 15th century. It has not been found in Ireland, or any trace of its existence recorded there.

There are two living species of beavers, the one inhabiting Europe and Asia (*Castor Fiber*) being still found in Siberia on the river Pelyin, five having been captured there so recently as 1876; and a few colonies exist on the banks of the Weser, Rhone, and Rhine. Lord Clermont in his "Guide to European Quadrupeds," published in 1859, stated, "it is found in greatly reduced numbers on the Danube, Rhine, and Rhone, on which last it inflicts considerable injury to the willow plantations." It is rare in Russia, except on the Dwina and Petchora, but numerous in Tartary and the Caucasus.

The other variety (*Castor Canadensis*) inhabits North America, comprising in its range a district bounded on the south by California, on the west and east by Vancouver's Island and Newfoundland, and north by the limit of trees, some distance within the Arctic circle.

Along with these two species lived in Pre-Glacial times a gigantic beaver known to science as Cuvier's. It did not, however, survive the Glacial period. The smaller and more recent species possibly withstood the intense cold by migrating to southern Europe. The comparison in size between these two beavers, at one time contemporaneous, coupled with anatomical characters, seems to preclude the possibility of the larger being a more highly developed race of the smaller.

The bones of beavers have been dug up in the lower brick earths of the Thames and under the streets of London; and there can be no doubt that at one time the beaver built its dam on this river and its tributaries. Its remains were also found by Pengelly in Kent's Cavern, near Torquay.

In appearance the beaver is like a great rat—about two feet long and one foot high, its body thick and heavy, weighing about 34lbs.; the head is compressed and somewhat arched at the front, the upper part rather narrow, the snout much so; the eyes are placed rather high on the head, and the pupils are rounded; the short ears are almost concealed by the fur; the skins (a good one when dried weighs about 2lbs.) are covered by two sorts of hair, of which one is long, rather stiff, elastic, gray two-thirds of its length, the remainder being tipped with shining reddish-brown points; the other short, thick, tufted, and soft, being of different shades of silver gray or light lead colour; the hair is shortest on the head and feet; the hind legs are longer than the fore, and the hind feet only completely webbed; there are five toes on each foot; the tail is ten or eleven inches long, and, except the part nearest the body, entirely covered with hexagonal scales; it is flattened horizontally, and nearly oval in shape. From a habit the creature has of giving self-satisfied slaps with this organ, the idea has been entertained that it uses it for a trowel; but this is now known to be an error; it is certainly employed as a means of alarm.

The incisor teeth are semicircular in shape, the enamel orange-coloured and intensely hard. Before the introduction of iron the Indians fixed them in handles and employed them as chisels for carving wood and horn.

These animals secrete a peculiar substance known as castoreum, extensively used by the slave and dog-rib tribes of Indians in the manufacture of medicine, and as a perfume for enticing both beaver and lynx to the traps or snares laid for them.

The flesh and tail are amongst the most prized dainties of Indian epicures: the former when first smoked and then broiled is not at all unwelcome food; the latter when boiled is a noted article of trapper luxury, though, forsooth, if the truth must be told, somewhat gristly and fat, and rather too much for the stomach of anyone but a north-western hunter or explorer. "He is a devil of a fellow," they say on the Rocky Mountain slopes, "he can eat two beavers' tails."

The scrapings of the beaver's skin form one of the strongest descriptions of glue, not affected by water, and used by the Indians as paint for their paddles.

Smellie, in his "Philosophy of Natural History," devotes a chapter to the Society of animals, in which he reminds us that the associating principle from which so many advantages are derived, is not confined to the human species, but extends in some instances to every class of animals.

Man possesses a portion of the reasoning faculty highly superior to that of any other animal. He alone enjoys the power of expressing his ideas by articulate and artificial language. With its aid, and the habit of association, the human intellect in the progress of time arrives at a higher degree of perfection.

Society gives rise to virtue, honour, government, subordination, art, science, order, happiness; under its auspices, as in a fertile climate, human talents germinate and are expanded, the mechanical and liberal arts flourish: poets, orators, historians, philosophers, lawyers, physicists, "microscopists," and theologians are produced, and its advantages are immense despite the inconveniences, hardships, injustice, oppressions, and cruelties which too often originate from it.

Now Society may be divided into two kinds—1st, Proper Societies, in which the individuals not only live together in numbers, but also carry on operations having a direct tendency to promote the welfare of the community; and 2nd, Improper Societies, in which the individuals merely herd together from the love of company, without carrying on any common operation.

Next to the intelligence exhibited in human society, that of the beavers is most conspicuous. Their operations in preparing, fashioning, and transporting the heavy materials for building their winter habitations are truly astonishing, and when we read their history we are apt to think we are perusing the history of man in a period of society not inconsiderably advanced.

It is only by the united strength and co-operation of numbers that the beavers could be enabled to produce such wonderful effects; for in a solitary state, as they at present appear in some northern parts of Europe, the beavers are timid and stupid animals; they neither associate, nor attempt to construct villages, but content themselves with digging holes in the earth.

Like men under the oppression of despotic governments, the spirit of the European beavers is depressed and their genius extinguished by terror and a perpetual and necessary attention to individual safety.

The northern parts of Europe are now so populous, and the animals there are so perpetually hunted for the sake of their furs, that they have no opportunity of associating, and of course those wonderful marks of their sagacity, which they exhibit in the remote and uninhabited regions of North America, are no longer to be found.

The society of beavers is one of peace and of affection. They never quarrel or injure one another, except during the period of courtship, for even amongst beavers Eve is ever the cause of evil, but live together in different numbers, according to the dimensions of particular cabins, in the most perfect harmony.

The principle of their union is neither monarchical nor despotic, for the inhabitants of the different cabins, as well as those of the whole village, seem to acknowledge no chief or leader whatever. Their association presents to our observation a model of a pure and perfect republic, the only basis of which is mutual and unequivocal attachment.

I have already drawn your attention to the difference that oppression occasions in the animate works of nature, and this because I find in reading numerous authors on the subject that their accounts of the works and their opinions of the intelligence of these most interesting mammals differ very considerably, and at the same time with much apparent truthfulness. I also note that the older observers, *i.e.*, those who studied these animals when their fur *first* came into great request, and therefore at a time when persecution had not wrought its natural result in the degradation of the species, give glowing accounts of their wonderful villages; whilst living writers "pooh-pooh" all this as a legend, and declare their structures, though parallel in idea, to be slovenly and indifferent. I shall prefer those descriptions which best illustrate the palmy days of the species.

In the fall of the year the beavers generally migrate up stream to a more favourable situation for procuring a supply of winter food. About January their tracks may be seen in the snow near the outlet of the lakes, where young fir trees abound, their bark now being preferred, as the sap has not risen in the willow and alder; some of the beavers become torpid during January, especially those living near lakes, swamps, or large sheets of water, which are frozen.

If February is open the beavers begin to come out of their retreats and frequent any running water near them; but it is generally March before the bulk of them vacate their winter quarters. When they appear they are lean, but their furs are still good, and continue so until the middle of May.

About the end of March they begin to "call." Both males and females "call and answer" one another. Sometimes on one "calling" half-a-dozen will answer from different parts of the lake. They occasionally "call" as late as August. Males fight during this season most fiercely; hardly a skin is without scars, and large pieces are often bitten out of their tails.

The young are born about the end of June, and are about three or four in number; but whether produced in the houses, hovels, or amongst the sedge, is not known for a certainty.

When this interesting event is expected, the old male takes the young of last year (for sometimes as many as three generations will remain around the paternal abode) and retires several miles up a river, considerately remaining there as long as requisite.

The young at first are called "kittens;" when twelve months old, "small medlars;" at two years, "big medlars;" and in the third year, when they also have families, "old beavers."

About the months of July and August the male beavers and last year's young, who have been enjoying the spring and summer amongst the woods, collect in large numbers on the lakes and watercourses, on which they had left their houses and females in the spring, for the purpose of uniting into society, and of repairing or adding to their villages.

These villages are very interesting, and consist of hovels, cabins, and stores, with the addition, in the case of a watercourse, of a dam, which is not required if the village is situated on a lake.

The following description will give you a good general idea of the whole arrangement, to which I will afterwards add some further details:—

In rivers or brooks where the water is subject to risings and fallings, they build a bank, which traverses the watercourse from one side to the other like a sluice, and is often 80 to 100 feet long by 10 or 12 feet broad at the base. One on the Metapediac in New Brunswick was 150 yards long, and by its aid the beavers had converted a stream about 15 or 20 feet wide into a pool an acre in extent and 8 feet deep in the middle. This dam was semicircular and convex to the stream. The spot for building it had been chosen with remarkable judgment, and all natural features, such as little islands, rocks, and stumps of trees, had been turned to good account. The centre of this dam was about 5 feet high, and so compact that it took two men with axes an hour to cut a 6-feet aperture through it.

The camp was situated near the centre of the pool, on the original bank of the stream; it was about the size and shape of an ordinary haystack, a little flattened down; rather more than two-thirds, about 8 feet, showed above the water; internally it contained one large circular apartment about 6 feet 6 inches in diameter; the roof, which was dome-shaped, being 2 feet 3 inches high in the centre, gradually sloping downwards to the edge; the floor was 10 inches above water mark, and contained four beds, made of chips of wood cut very fine; the walls were from 4 to 5 feet thick, made altogether of earth and wood. There were three entrances, all under water.

Close to the camp was the storehouse, an accumulation of fresh logs and branches submerged in the water for winter use. There must have been half-a-dozen ordinary cart loads. They had been hauled 60 yards by land and twice as far by water. Trees of all sizes, from a foot in diameter downwards, that had been felled by the beavers, lay scattered all around the pond and in the water, some freshly cut, others decayed and covered with moss. The boughs of the larger ones had been lopped off and carried to the storehouse, the bark of the stems being eaten on the spot. Smaller trees had been felled, cut into logs, and carried bodily off. Saplings the size of an axe handle had been cut as with one slanting blow of an axe, but the larger trees were gnawed all round, and dry sticks and roots that obstructed their roads had been cut neatly off at the proper breadth and the pieces thrown aside.

In constructing a dam the beavers select a spot where two trees grow opposite to one another on each bank. These they fell in such a way that they meet in the bed of the stream, and are inclined upwards. This done, more trees above are cut down, and the pieces dragged along the roads I have described to the water and floated, under the guidance of two or more beavers, who take advantage of all side eddies as will suit the purpose, to the dam, against which they are placed horizontally. The interstices are next most carefully filled with grass, fibres, and tempered clay. Nature now lends her assistance by accumulating against the upper side the *débris* which would otherwise have travelled far beyond. Some of the boughs strike root, and the dam becomes so strong as to be used as a bridge by man and beast. Occasionally flood holes are made in it to permit the passage of water after rain, and all damage to it from whatever cause is instantly repaired.

The dam being complete, and the water above it having been raised by its aid to a depth and width in proportion to the size of the colony, the next business is to build the houses, the sites of which are generally, but not always, chosen near the side. These are formed of water-logged sticks placed horizontally in the water; they have always two or more entrances, and a small chamber; the top of the house is very thick, to guard against attacks by animals (chief amongst these being the panther, wolf, and wolverine), and as this roof is added to every season it is sometimes eight feet through, and during frost frozen as hard as iron. Mud and roots are used to make the house solid, but no mud is seen from the outside, as the top is covered with loose sticks left there by the beavers after eating off the bark.

The "swell" houses have two flats, and may accommodate as many as sixteen beavers. The lowest is on a level with the water; the upper one is used to sleep in, and has communication with the water through the bottom; the top one has also direct and covered communication with another chamber on the land. The entrances, two in number, are subaqueous, and called angles, one being on the upper, the other on the lower side of the house.

The beavers usually have two houses, a summer house and a winter house (just as we have a town house and a country house). The former is generally situated near the mouth of the brook, as the food of the beavers during the summer months consists in great measure of the stems and roots of the pond lily (*Nuphar adrena*), which is called beaver-root by the settlers.

Whilst the winter house is building the beavers often live in a deep hole in the bank, which is called a "hovel" or "wash." The entrance to this hole is always under water, and when it has extended some distance inland it rises to a chamber which is not only high and dry, but has a ventilating hole for the admission of air.

Although birch and willow trees as large as a man's thigh are frequently cut down, the beavers appear only to make use of the smaller branches, which are cut into suitable lengths and carried to the house, near which they are sunk by means of mud until a very considerable pile of them is raised to some height above the water. The beavers always draw their supply from the base of this stack, so as to feed on the most sodden bark. Until winter compels them to consume this store they feed upon the land or upon browse collected on the top of the house. Their principal food, however, consists of the bark of the aspen, willow, birch, poplar, and occasionally the alder. They rarely resort to the pine tribe unless from severe necessity.

I will now proceed with my description of the BUTE BEAVERY, so that you may compare an account of their actual doings in free or unmolested confinement with the review of the habits of the species I have just concluded.

Having been favoured by Mr. Hughes, the great Birmingham Naturalist, with a letter of introduction to Mr. Barker, of Rothesay, and having also presented this letter and gained the latter gentleman's cordial co-operation, we started from the Queen's Hotel on a very beautiful morning, and after about an hour's drive stopped between two of the Mount Stuart fir woods, whilst my friend summoned the keeper, Black, from his cottage hard by, to show and explain the "Beavery" to us.

Crossing a stile and plunging at once into the depths of the wood, a sharp walk of some ten minutes found us close by a dwarf wall surmounted by a light iron fence. Climbing over this we entered an enclosure of some three acres, containing a valley whose banks were clothed with fir and an undergrowth of bracken, whilst along the bottom trickled a tiny burn. Within this space the Marquis of Bute, about four years since, turned out two pairs of beavers; but as he did not know then that they required willow bark for their sustenance one pair perished. On willow branches being furnished to the other two they prospered, and at the present time (*i.e.*, 1878) have increased to sixteen; and not only so, but curiously enough, the locally bred beavers have adapted themselves to their environment and taken to feeding on the fir bark, sooner than eat which their predecessors succumbed.

The first thing that attracted my attention was a broad yellow ring round the base of many of the trees, and as we got nearer I saw they had been beautifully cut by the teeth of these animals, the chips (of which I brought a few to show you) being profusely scattered around. Then I observed that many trees were prostrate, and others quite ready for the final cut to fell them. When engaged in this operation the beavers sit on their haunches, and, taking two horizontal cuts, tear out the piece between them, exactly as a carpenter does when reducing wood with his chisel; and in order to cause the tree to fall in the required direction (never failing in this unless an adverse wind springs up at the critical moment) they cut the wood *away most* on the *opposite* side, leaving a slender support a little thicker, but not much thicker, than one's wrist. At this stage the beavers retire a little and inspect the tree, then all but one move to a safe distance, and that one proceeds cautiously with the cutting until the tree, with a graceful motion, obeys the will of its persecutor.

As soon as the tree is down, the beavers separate the branches close to the stem and carry them away, then eat the bark off the butt, after which an old beaver scores the latter at equal distances of about two or three feet to indicate the spots at which it is to be divided into logs by the others.

They had also been very busy tearing up the grass and turf in search of "Tormentil root." We followed their example, and on tasting it recognised strongly the flavour of acorns.

At this point the keeper again drew my attention to the little brook, whose top, so narrow was it, was often hidden with overhanging ferns, and assured me it was originally exactly the same right through the enclosure. Guess my astonishment then, for I had not heard so much about beavers at that time as you have to-night, when on turning a little knoll we came in view of a decent sized pond with a round island in the middle, and a dam at the lower end, making an average depth of about three feet of water. Proceeding a short distance farther we came upon a good fair pool, the size of which you may judge from the enlarged sketch I have here, which was published in the January, 1878, number of the "Animal World," and taken on the spot by Mr. Walter Severn.

The dam at the lower end of this pool is semicircular, convex to the stream, 62 feet long by 10 feet wide, the greater part being under water and sloping to the pool. The top was about two feet wide, and so strong that the three of us walked over without hesitation or difficulty. One of the boughs used as a backing was as thick as a man's leg. Black, who frequently spends a night at the top of a tree to watch his charges at work (under the disadvantage of their doing most when the nights are darkest), saw this log deposited. He said the beaver floated it down stream to the dam, on which it climbed and drew the log after it; then, placing the thin end against the back edge of the dam, it took the butt in its paws, and raising itself to its full height pushed it with such force and precision that it was at once so firmly fixed that although we grasped it fairly no movement was perceptible. In another spot a horizontal bough had been carefully wedged behind an upright fork.

The sloping face of the dam was composed of clay and stones, the original material of the present ponds. This clay they puddle with their feet, make into balls, and pile in a heap in the middle of the pool until required. In carrying it through the water they hold it between the fore paws and the chin, swimming with the tail and webbed hind feet. If alarmed, or when in the act of diving, they strike the water with their tails, and thus occasion a loud report.

Their house, which is near the right bank, looking down stream, is 9ft. high (5 of which are above water), 10ft. long, and 8ft. wide, oval in shape, and difficult, in spite of its size, to recognise at first, owing to their having nearly covered it with growing turf, boughs and stems of fern, the leaves of which they had eaten. Along the top was a backbone of boughs left open as a ventilator, and through which heat was perceptibly rising from the chamber within. Close to the water on the upper side was a narrow terrace, on which Black said the tenants liked to sun themselves when all was quiet.

My friend climbed on the top of the house, to the consternation of the inmates, who bolted in all directions, their hidden tracks being marked by lines of rising bubbles. In stepping back to land he put his foot on a tree stump, and instantly fell all his length. We found he had gone through to the land chamber of the house. Black was horrified, I was delighted, and at once commenced an inspection.

This chamber was as big as a wheel-barrow, and contained two beds of wood shavings like spills (a few of which I brought away), which are prepared by the beavers from the small boughs on the bark of which they have fed. The house side of this chamber had been built of boughs and sods, the projecting ends of the branches being neatly dressed off, and the stump of the tree had been hollowed until only a thin shell remained, which accounted for its having given way so unexpectedly.

In the centre of the pool they collect their winter store of boughs, which, when complete, stands high out of the water, and is used from below.

Round the sides of the pool they have made several burrows, or "washes," or "hovels," as they are variously called, which penetrate from 20 to 30 feet into the bank, where they rise above water-level and form a small chamber, in the top of which an air hole, stuffed full of sticks, is made from the inside for ventilation but not for egress. Between the submerged entrances to these holes, and the equally subaqueous approaches to the house (one being on the upper and the other on its lower side), they have cut grooved channels in the bottom of the pool, which conduct them safely when diving from one to the other. Upon the bank they have numerous runs terminating in shallow water, the sides of which are marked by the *débris* of ferns and twigs.

Their working hours are between 7 o'clock at night and 7 o'clock in the morning. One beaver is always on duty at each dam, and whatever they do is achieved with great rapidity. Black thinks they breed in January, but all authorities are against this opinion, which is probably owing to the kittens first appearing in public about that time of the year.

One fault alone I had to find with my little friends, and that was the apparent extravagance with which they had "ringed" a very high percentage of the standing timber in the enclosure, without intending to promptly finish the work, as evidenced by the stale appearance of the chips.

Beavers are captured either by trapping, drawing, or by storming their fortresses.

In the first instance an iron trap is set close by the bank in shallow water, but with chain enough to reach into a depth of at least four feet. Upon the bank above a little castoreum, mixed with rum or cinnamon, is spilt; the beaver is attracted by the scent, and when caught dives into deep water, where the weight of the trap holds down and drowns it. Should it, by reason of the river having fallen, not reach the deep water, it will bite off its leg at a joint, draw the sinews out of the shoulder, and escape.

The second method consists in noiselessly removing part of the dam. As soon as the beavers find the water sinking they come out of their houses and holes to repair the breach, and are then shot.

Thirdly, the Indians search round the beaver pools for the "washes," opposite each of which they make a hole in the ice; the women then break intc the beaver-house, which affords the unfortunate animals the choice of three evils—either to stay under the ice and get drowned, or to stay in the house and be killed by the women, or bolt to their "washes" and be killed by the men, who detect their entrance by the ripple in the ice-hole as they pass under, when the aperture is immediately staked, the "wash" opened from above, and the poor beast caught, either by hand or with a hook made for the purpose. Sometimes they merely stake the two entrances to the house, break into it, and spear or tomahawk the imprisoned beavers; or, if it is a lake, simply frighten the beavers out of their houses and shoot them as they come to the surface, as they cannot long exist without air.

In 1808 the Hudson's Bay Company imported 126,927 pelts, each worth about 19s.; in 1820 only about 50,000, showing how rapidly their numbers were decreased.

The fur when shaved off the pelts with a sharp knife was winnowed in a tube to separate the long hair from the wool; the latter was then kneaded into felt, through which it worked until it appeared as a perfect surface on the other side, and was ready to make into hats.

As pets in confinement, beavers are most affectionate and entertaining. Did time permit I could give you numberless anecdotes of their sagacity; but the length my paper has already reached precludes any such extension. I trust that in what I have told you there is sufficient to convince you that if we, lords and tyrants of creation as we are, vacated the earth, the lower organisms of which the subject of our paper to-night is a good example, would find their lives far more agreeable, and a wider scope for the exercise of their intelligence.

How far it rests with man to render the lives of animals more endurable I leave with you, and in conclusion add—

> "The heart is hard in nature * * * *
> * * * * * * * that is not pleased
> With sight of animals enjoying life,
> Nor feels their happiness augment his own."

Plate IV.

b × 360

Fig. 1. a × 88

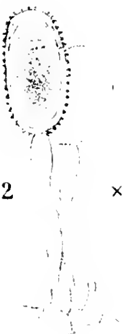


Fig. 2 × 500

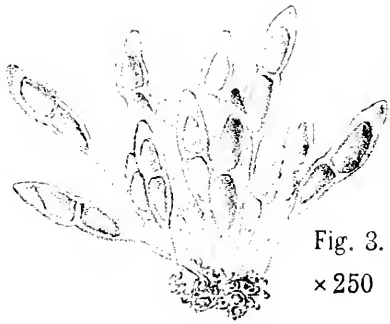


Fig. 3. × 250

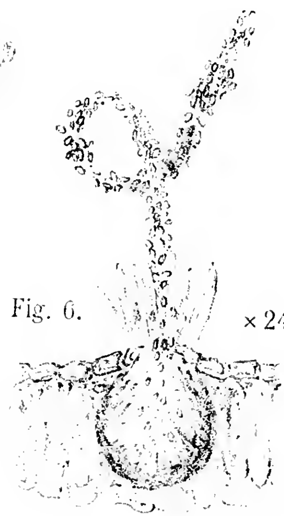


Fig. 4. × 240

Fig. 5. × 400

Fig. 6. × 240

THE UREDINEÆ

W. B. G. LITH

NOMAD FUNGI: THE RECLASSIFICATION OF THE UREDINEÆ.

BY W. B. GROVE, B.A.

Read before the Society, October 17, 1882.

In choosing the title "Nomad Fungi" for my paper, I was thinking chiefly of what are called the heterœcious species—that is, those which wander during their annual life-cycle from one plant to another, as will be afterwards detailed. But it occurred to me also that the words would bear another and very apposite meaning in reference to the travels of these fungi in their book-classification, for the species of some genera have been handed about from one place in the scheme to another in such a way as fully to justify their claim to the name of experienced travellers. You will perceive that I shall have again to treat of the subject of classification, which is generally considered a very dry one. In the notes which I had the honour of reading before this Society on the Myxomycetes, the central point of interest was as to the position which those organisms should occupy—*i.e.*, whether they should be placed in the animal or the vegetable kingdom, and you may perhaps remember that, as might be expected, I ventured finally to decide in favour of the latter. Now I think all who have studied that particular point, and the evidence bearing upon it, will admit that the question, though it be merely one of classification, was of surpassing interest, partly derived no doubt from the fact that the border-land between the animal and vegetable kingdoms, though it has been the battle-ground of many a long-decided controversy, is still as uncertain as that which separates Greece from

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REFERENCES TO PLATE IV.

Fig. 1.—*a*, Section of two cups of *Œcidium grossulariæ*, showing the spores originating in chains beneath the epidermis, × 88; *b*, three spores, × 360—(from nature).

Fig. 2.—Two uredo-spores of *Puccinia graminis*, seated on their pedicels, or basidia, × about 500—(after De Bary).

Fig. 3.—Group of teleuto-spores of *Puccinia graminis*, × 250—(from nature).

Fig. 4.—Germinating spore of *Œcidium tussilaginis*, × about 240—(after Plowright).

Fig. 5.—Germinating teleuto-spore of *Puccinia magnusiana*; each segment of the spore has thrown out a germ-tube, bearing three "sporidia," × about 400—(after Plowright).

Fig. 6.—Spermogone of *Œcidium tussilaginis*, emitting a tendril of minute spermatia in water, × 240—(from nature).

Turkey. The scene is now shifted; we have to deal with a series of fungi, about whose vegetable nature not even the most ardent zoologist could doubt. But though the interest is different, it is, it appears to me, even greater than before. At least, to one who has not previously studied these leaf-fungi, the search reveals almost as many surprises, as unexpected conclusions, as startling transformations as any other branch of Natural History could furnish.

Classification of the Group.

To make the subject of our discussion clear, it will be as well to begin by giving an outline of the classification of this group in the famous Friesian system, which has been hitherto adopted in England. Of Fries's six great classes one is the Coniomycetes, or *dust-fungi*, so called from the fact that the dust-like spores form its principal feature. I have already pointed out on one occasion how artificial this system is in some respects, and described one modification of it—in respect to the Myxomycetes—which it is now undergoing in England. In this much-needed reform English cryptogamists linger, I am sorry to say, far behind their brethren of the Continent. We are now concerned with another reform as pressing, and of course as hesitatingly accepted on this side of the Channel, and it is safe to say that one still more important will have to be made in the not distant future.

But, though most of these six classes appear to require revision, there is not one which contains such a heterogeneous collection of odds and ends as the Coniomycetes. It may truly be said that the only point in which they agree is in the vast predominance of the spores over the other parts of the fungus In any other point of view they are widely and irreconcilably unlike. Some produce enormous quantities of minute spermatiform spores in receptacles, more or less perfectly formed, in or upon dead or dying leaves and stems, or underneath the bark of twigs and branches, as, *e.g.*, that army of obscure species which form little dark spots on fading leaves, and which are probably all mere phases in the life-history of a so-called higher fungus, known under another name. Others produce their spores freely on the outer surface of dead stalks, bark, and leaves; such as the common Torula, which—I may be excused for reminding you—has nothing to do with what a mistaken analogy led us formerly to call the Torula or yeast-plant, and which is now called Saccharomyces. This latter does not belong to the Coniomycetes.* The third and last division—the one with which we have now to deal—grows upon living plants, and includes the majority of those species which are usually known under the name of leaf-fungi. It was divided into three orders—the Pucciniacei, the Cæomacei, and the Œcidiacei; and the following genera:—

* The group of the Torulacei should be absorbed among the Hyphomycetes, into which it passes insensibly. There will then be no Coniomycetes left.

PUCCINIACEI.

Xenodochus.	Triphragmium.	Gymnosporangium.
Phragmidium.	Puccinia.	Podisoma.

CÆOMACEI.

Tilletia.	Urocystis.	Cystopus.
Ustilago.	Uromyces.	Uredo.
Thecaphora.	Coleosporium.	Trichobasis.
Tuburcinia.	Melampsora.	Lecythea.

ŒCIDIACEI.

Rœstelia.	Œcidium.	Graphiola.
Peridermium.	Endophyllum.	

The Pucciniacei or "Brands" were distinguished by having compound spores—that is, spores divided by septa into two or more cells; the Cæomacei or "Smuts and Rusts" were distinguished by the free spores being mostly simple or one-celled: while the Œcidiacei or "Cluster-cups" were characterised by their simple spores being contained in a cellular envelope or *peridium* of various forms. A beautifully simple plan, well adapted for the purpose which it has hitherto served and will continue to serve, as a kind of Linnean system in miniature, an index in which the names of one's finds may be readily discovered, but not representing in any way the natural relations of the objects. In the first place the system was broken—even in England—by the admission of a large number of the Cæomacei among the Pucciniacei, as when the "rust" of corn, *Trichobasis rubigo-vera*, was set down under *Puccinia graminis*, the "corn mildew," of which it was considered merely an early phase; or again, when the round simple spores of the early stage of Phragmidium are classed with the long three to six-septate spores of the later form. But the condition of the Cæomacei was worse. It included the bunt and smut of corn which have simple spores; the Buttercup smut and other allied species (Urocystis) which have compound spores; the Coleosporia and Melampsoræ, each of which produces spores of two distinct kinds, just as Puccinia does, and demands, by every rule of classification, to be ranked with it; and, finally, it contains a genus (Cystopus) which has absolutely nothing in common with the others, and is, in point of fact, closely allied to a genus, Peronospora, the Potato-fungus, which is itself classed with dissimilar species in another group, the Hyphomycetes. The Œcidiacei was the only order which approached the requirements of a rational system.

It is true that a great deal of what is now known was unknown fifty years ago, while some facts have only recently been discovered; but it nevertheless remains that British mycologists must plead guilty to clinging obstinately to an obsolete system, which has long been abandoned on the Continent. The true interpretation of the facts has been published for many years, but we in England have heard nothing (at least among mycologists) but murmurs about "mad fancies for change," "startling vagaries in vogue in certain quarters," "pandering to the desire of novelty," etc., with an intimation that the writer retained a preference for the steady old British jog-trot, though it land him far in the rear of the rest of the world. To suppose that, though a few hundreds of Continental physiologists all unite in testifying to their belief, founded upon experiments,* in the necessity of a total change in the classification of the leaf-fungi, yet we in our island shall continue to regard the facts as unproved, is conceited, not to say absurd. What do we want? Can we not trust biologists, other than Englishmen, to make their experiments carefully and record their conclusions truthfully? The progress, and especially the manner of the progress, of other branches of science certainly does not warrant such a conviction. Are we to regard all their testimony as doubtful, and possibly *untrue*, until some British experimenter deigns to bestir himself.

Happily, the question need no longer be asked. The British experimenter has bestirred himself, and to one of our leading mycologists, Mr. C. B. Plowright, of King's Lynn, belongs the high honour of being the first to remove this stain from British science. His words are, in the light of the past, so remarkable that I cannot do better than quote them in full. "So far as I know," he says, "no one in this country has taken the trouble to put the matter to the test of experiment. For my part, it may be said that, having conducted upwards of a hundred cultures during the past two years, I have no doubt whatever upon the subject. We are putting ourselves in a hypercritical position if we refuse to believe what competent observers assert, simply because we have not ourselves actually seen it."† And let me add that the state of the case is not improved when the "competent observers" are of a foreign race, and the unbelieving spectators belong to this favoured nation. We are often reproached for our insularity, and it is certain that we have often fallen behind the science of the age by incredulous contempt for foreign observers. I rejoice, therefore, to see Mr. Plowright strike the first blow at that body of errors which has hitherto passed for knowledge about leaf fungi in Britain—that house of cards which now, at the touch of Ithuriel's spear, falls "like the baseless fabric of a vision."

The Revised Classification.

You will best appreciate the extent of the change if I place before you Dr. Winter's revised classification, so far as it relates to British species, and compare it with the one now obsolete :—

USTILAGINEÆ.

Ustilago	Tilletia	Urocystis
Sorosporium	Entyloma‡	

* See "Comptes Rendus," 1880, and "Botanische Zeitung," *passim.*

† "Science Gossip," September, 1882, p. 196.

‡ The species of this genus discovered in Britain are recorded in the pages of Grevillea under the name of Protomyces.

UREDINEÆ.

Uromyces
- I. Œcidium
- II. { Uredo or / Trichobasis
- III. Uromyces

Puccinia
- I. Œcidium
- II. { Uredo or / Trichobasis
- III Puccinia

Triphragmium
- II / III { Triphragmium

Phragmidium
- I. / II { Lecythea or / Uredo
- III Phragmidium

Gymnosporangium
- I Rœstelia
- III Podisoma

Cronartium { II. / III.

Melampsora
- II. Lecythea
- III. Melampsora

Coleosporium
- I. Peridermium
- II. / III. } Coleosporium

Endophyllum

The triple division, into Pucciniacei. Cæomacei, and Œcidiacei, has ceased to exist, because these three orders typify only three stages in the life-history of one and the same fungus. The Ustilagneæ comprise such of the Cæomacei as are found to differ remarkably from the others in the mode of germination of the spores; with these we have nothing further to do. The genera which enter into the other group, the Uredineæ, are nearly all characterised by what is known as *Pleomorphism*—that is, they pass in their annual cycle through several distinct phases, which are so different that, prior to experiment and extended observation, they were placed—and rightly too—in distinct genera or orders. An exactly similar case is well known to zoologists in regard to the classification of the Entozoa. In the table given above, the names placed underneath the genera, with I., II., or III. prefixed, are the names of those pseudo-genera of the Handbook which now represent mere stages of growth.

Description of a Uredinous Fungus.

To show the position in which the problem stands, let us suppose that we are a band of students just setting out on the study of the leaf-fungi. Let us go into the country on some day in early spring, and gather a few leaves of the common violet. We shall find some of them marked with pale yellowish spots, and looking underneath the affected leaves we shall see a slightly swollen roundish patch, on and in which is seated a cluster of cup-like bodies, filled with orange spores. The fringe or brim of the cup consists of the ragged edges of the covering (called a *pseudo-peridium*) by which the spores were enclosed, when the fungus was in a less advanced state. Similar clusters of cups, only elongated in form, are found on the petioles and stems, in fact on all the green parts of the plant. The spores are roughly spherical or polygonal, orange-yellow, covered with fine warts, and bounded by a very thin cellulose membrane. These spores are given off in chains by a process of budding from the ends of delicate threads, called *hyphæ*, with which the bottom of the cup is clothed, in such a manner that the spore which is at the free end of the chain is the oldest, while that which is at the end of the hypha is the youngest, and has in the process of its growth pushed the whole chain of those previously formed up towards the mouth of the cup. A fungus, which possessed characters similar to these used to be called an Œcidium, and the particular one of which we are speaking was called *Œcidium violæ*. This Œcidium is found on the violet in May and June.

But, later on in the year, we find on the leaves of the same plant a fungus of a very different character. There is no cup, no chains of spores; the spores are collected in loose rounded heaps, resembling the sori of ferns, apparently resting lightly on the epidermis of the leaf, not usually combined in clusters, but scattered over the surface. Instead of the beautiful white fringe which surrounds the Œcidium, we have here merely the ragged edge of the ruptured epidermis, showing that the fungus originated just beneath the epidermis, and in its growth burst it open. The oval spores are brownish, and each is formed singly by a constriction of the end of a hypha, but otherwise they are very similar to those of the Œcidium. This fungus used to be known as *Trichobasis* or *Uredo violarum*.

At the same time, or later, we can find on the same leaves still another fungus of a different kind. In this case the spores grow, as in the Uredo, from the ends of the branches of the hyphæ, and frequently, if not always, from the same mycelium which has hitherto produced the Uredo-spores. The sori are surrounded, in the same way, only by the ruptured epidermis. But the spores are very different in character. While the Uredo-spores are easily detached from their support, these often remain firmly fixed to the hypha from which they originated, which breaks off with them as a kind of stalk; each spore consists of two cells, separated by a transverse partition, or rather two spores are produced on each hypha, for each cell of the compound spore is capable of independent germination. The greatest difference of all is, however, in the cuticle of the spore, which in these is greatly thickened and strengthened, in the same way as the outer surface of the epidermal cells of many leaves is cuticularised, in order to enable it the better to resist the attacks of the weather. This last form of fungus is called a Puccinia, and our species is known as *Puccinia violarum*.

Now undoubtedly the first impulse of the student, on seeing these various kinds of fungi, would be to class them as three distinct species, belonging to three distinct genera, and placed respectively in the three orders which have been mentioned above. But this impulse, though natural, could not stand the test of a more careful examination. Our student would find the same sequence of phenomena on other species of plants. The common Epilobiums would provide him with three fungi, successively making their appearance on the leaves, in the same way and in the same order, viz., *Œcidium epilobii*, *Trichobasis epilobii*, and *Puccinia pulverulenta*. The species of Allium, of Primula, of Mentha, of Galium, of Sanicula, and many others, all tell the same tale. This should have awakened suspicion, but at first apparently did not. Moreover, the Uredo and Puccinia-forms appear, as I have said, often on the same leaves at the same time, and are obviously seen to spring from the same mycelium, not only in the species which I have mentioned, but in very many others. This fact, when fully brought to light, was so far conclusive; and the phenomenon was known under the name of Dimorphism. Those who have read Mr. Cooke's useful little book on

Microscopic Fungi will remember that he devotes a chapter to the exposition of this theory of Dimorphism, and in his Handbook the theory is practically followed up by the arrangement of the various forms of Uredo with the species of Puccinia to which they belong, so far as that was known. It is true that Cooke calls most of these Uredos *Trichobasis*, and professes to distinguish between the two genera by assigning to the spores of the latter the possession of a foot-stalk, while the spores of Uredo, he says, "have no foot-stalk at any stage of their existence." In fact, in the generic character of Uredo he seems to assert that the spores of Uredo are developed by a kind of segregation of the contents of certain hyphal cells, that is, by free cell-formation. But this is untrue, unless Professor De Bary be totally mistaken. The spores of Uredo are formed by constriction from the end of a hyphal filament, which, when thus engaged, is called a *basidium*. There is no difference between Uredo and Trichobasis, except that in the latter case, in a few instances, a small fragment of the basidium remains attached to the spore.

But while the Dimorphism of these fungi was admitted, the fact which still remained behind, namely their Trimorphism, was as yet undiscovered. If the case had been with all the Uredineæ as with those which I have mentioned above, no doubt the fact would soon have forced itself upon the mind. No one could long contemplate the orderly procession of the three forms on the same plant without being compelled to acknowledge the probability of their genetic connection. But, unfortunately for the mycologists of the past, the case was by no means so simple. Many species of Œcidium were, and still are, known which are not succeeded by a Uredo or a Puccinia on the same plant. Many Uredos were, and a few still are alone, unaccompanied by either an Œcidium or Puccinia; while there is a considerable number of species of Puccinia with which no Œcidium or Uredo was or is even now known to be associated. Still another fact complicated the matter. Allowing that a Puccinia is preceded by an Œcidium, it seems that we must not always look for the Œcidium upon the same or even upon an allied plant. Sometimes we shall find the Œcidium upon a Dicotyledon, while the Uredo and Puccinia luxuriate upon a Monocotyledon. This, which is known as *heterœcism*, is a curious fact, and is especially the case with those species such as *Puccinia graminis*, *P. coronata*, *P. poarum*, *P. magnusiana*, and *P. caricis*, which grow upon grasses and sedges in their final stage. These are called *heterœcious* species, and their Œcidia are found respectively upon Berberis, Rhamnus, Tussilago, Rumex, and Urtica.

Life-History of a Heterœcious Species.

It will illustrate this important phenomenon of heterœcism, as well as confirm the whole theory, if I trace the annual cycle of *Puccinia graminis* through its various forms; for, if it is once proved that *P. graminis* is descended from *Œcidium berberidis*, no one can any longer conceive a doubt about the truth of the theory in the other or *autœcious* species, where the various forms appear on the same plant.

This Puccinia (viz., *graminis*), then, begins its life in spring as an Œcidium, or cluster-cup, on the leaves of Berberis, usually upon *Berberis vulgaris*, the common wild barberry, but also upon most of the cultivated forms. If the spores of this, when ripe, be taken and sown upon the leaves of a young wheat plant, which has never been exposed to the risk of any accidental infection by other spores, it germinates, throwing out a germ-tube. This germ-tube travels over the leaf, searching for a stomate into which it may enter. As it elongates it assumes a spiral form. Sometimes after making four or five turns from left to right, it will reverse its motion, and make the succeeding turns from right to left. It is obvious that by these means it adds greatly to its chance of finding and entering a stomate; in fact, this motion, and the object of it, are very similar to that which Dr. Darwin has so recently made known with reference to the growing radicle of flowering plants. Mr. C. B. Plowright, to whose experiments I am now referring, says that all the trouble he took in conducting his experiments was fully repaid by the intense pleasure of watching this germ-tube feeling its way over the epidermis of the wheat-leaf in search of the opening by which alone it could enter in. Having obtained an entrance, the tube, by repeated branching, forms a mycelium, which increases within the plant tissues, and at last the ends of the hyphæ turn upwards towards ths surface, forming an hymenum or layer of basidia. Each basidium, by constriction from its extremity, forms a uredo-spore, which assumes a deep yellow or orange colour. As the mycelium continues branching, and each branch produces a spore, the increasing mass at last ruptures the epidermis, and the spores escape. Now these spores, like those of the Œcidium, have only a thin cellulose coat; they are evidently adapted for germinating immediately. This is in fact what they do; each uredo-spore, if it falls upon a leaf of the wheat-plant, germinates at once, throws out a germ-tube, which searches as before for a stomate by which it enters, and forms a new mycelium, which produces again uredo-spores. By repetition of this process, the fungus spreads itself from plant to plant over a large area. The spores are easily dispersed by wind and rain.

But these spores, though evidently adapted by their vast numbers, their ready dispersion, and the ease with which they germinate, for effecting their object, namely—the rapid diffusion of the fungus, evidently do not furnish the best conditions for prolonging its life through the trials of winter, and preserving it to afflict the agriculturist in another year. These thin-coated spores lose their power of germination in a few weeks. Now see what the fungus does. Knowing what is coming, it takes the best means of ensuring its safety by producing spores calculated to resist the adverse influences of winter weather. Like a wise mother, it clothes its offspring in a warm greatcoat. In fact, it produces resting-spores, as do so many other organisms well known to the microscopists in this room. The same mycelium, which has produced uredo-spores all the summer, begins in autumn (influenced doubtless by the gradual ripening of the tissues of the wheat) to give off the puccinia-spores, which are not only two-celled—an unimportant circumstance *—but are distinguished by their thick cuticle, that peculiar dense waxy layer which the external laminæ of the cell-wall have the power of secreting if they wish to protect themselves against heat or cold. It is this layer which gives to a sorus of puccinia-spores its strikingly shiny aspect. Clothed in this extra garment, they lie snugly ensconced in the half-decayed tissues of their host, unchilled by wintry blasts, until the warmth of returning spring calls forth again the leaves upon which they are fitted to grow. In the case which we are considering the leaves for which they wait are those of the common barberry.

Here, however, is another difficulty. The puccinia spores are large and heavy—the hoplites of the fungal army; moreover, they are firmly attached to the basidia from which they spring, and not readily detached, as in the two other kinds. The wind and the rain can do but little to effect the transference of such a heavy brigade of spores as these from the surface of the ground to the young barberry leaves, which alone can furnish the requisite nidus. If the fungus had not still another resource in store, if it were now at its wit's end, the farmer might breathe a sigh of relief, for perhaps his crops would never be attacked by rust or mildew again. But all is not yet lost: the fungus is equal to the occasion. Each cell of a puccinia-spore, germinating where it lies, sends out a short tube, forming at the end a few branches (usually two to four), into which the protoplasmic contents of the cell pass; the ends of these branches are constricted off, and we get two or three little round spores (the so-called *sporidia*), which are admirably adapted for being blown by the wind wheresoever it listeth. Imagine one of these tiny spheres alighting on a barberry leaf; it germinates, sending out a germ-tube as before, but this time the tube does not seek for a stomate, but bores its way straight through the tender cuticle into the leaf. Here it forms a mycelium, from which, after a week or two, the Œcidium is again produced.

Thus the life-cycle is complete, and I venture to say that we have here as nice an instance of adaptation of means to ends, and as strange a story of transformation, as any which biology can furnish. This romantic tale is founded upon fact. Puccinia-spores have been sown upon barberry leaves and observed to germinate, and from the mycelium thus produced an Œcidium has been seen to grow; † similarly the production of the Uredo from the œcidio-spores has been actually watched, while the production of a Puccinia from the same mycelium as the Uredo is a matter of easy observation. Thus, as in so many other instances, a common belief of country people, after enduring from so-called men of science the customary stages of incredulity and

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* This is shown by the fact that in the genus Uromyces, which is in every respect analogous to Puccinia, these spores are one-celled.

† "Grevillea," xi. pp. 54-6.

laughter, has now become an article of science; and in a few years the man who dares to question it will be received with as much ridicule as were those who formerly believed it. The Norfolk farmers, and others, always held that the presence of barberry bushes in the hedges of their cornfields had something to do with the rust and mildew of their crops; and this belief, though doubtless founded upon rough reasoning only, turns out to be quite correct. Many other beliefs of country bumpkins, now held up to scorn as instances of superstition, will in future years become a part of the scientific creed.

A perfect Uredinous fungus has, then, three distinct stages—the Œcidium, the Uredo, and the Puccinia, distinguished by Continental mycologists as I., II., and III., as will be seen by referring to the table of the revised classification on pages 112-3. The spores of these are called, sometimes, protospores, stylospores, and teleutospores respectively; but the number of species in which all the three stages have been observed is comparatively few, and in the great majority either two or only one stage is at present known.

It must not be supposed, however, that a Uredine which has all three stages need pass through them every year. Just as in Phanerogams, a plant may have several modes of multiplication, of any of which it may avail itself according to circumstances. For instance, Mr. Plowright has shown that *Puccinia poarum* is a stage of *Œcidium tussilaginis*; yet the Puccinia has been hitherto unknown in Britain, while the Œcidium occurs in vast abundance everywhere. A similar, but reversed, instance occurred in another of his experiments, where he produced *Œcidium zonale* (a plant new to the British flora) by sowing the spores of *Uromyces junci*. Even if we grant that the newly-discovered fungi did exist before in Britain, it must be in small quantity and in few places only. So *Peridermium pini* is a stage of *Coleosporium senecionis*; the latter is very common miles away from any locality where the former can be found. Stages II. and III., *or their physiological equivalents*, must indeed occur in most cases; but the œcidium-stage need perhaps only occasionally intervene. *Vide infra.*

In the genus Phragmidium the œcidium-stage has been hitherto but little known (I might say, in England altogether unknown),* and frequently confounded with the uredo-stage. In both cases the sori are surrounded by a ring of paraphyses, but in the case of the œcidium-sorus the spores are produced in chains; in the uredo-sorus each spore grows singly. For Triphragmium no stage I. has yet been discovered,† which is also the case with our species of Melampsora. In Melampsora and Coleosporium, stage II. is the ordinary uredo-like form, in which the spores occur in heaps like dust; stage III. is that in which the spores are closely compacted; in Melampsora, 1 to 4-celled and with a

* Mr. Plowright has recently recorded it in "Science Gossip" for January, 1883, pp. 11-12.

† The uredo-stage has, however, two forms—the one appearing in spring, physiologically, perhaps, but not morphologically representing the Œcidium, the other in summer being the true Uredo.

thickened cuticle; in Coleosporium, mostly 4-celled and surrounded by a tenacious gelatine. Gymnosporangium (with which Podisoma is united) has for stage I. the various species of Rœstelia. Of Cronartium, which has been discovered in Britain since the publication of the Handbook,* only stages II. and III. are known. Peridermium is stated to be the first stage of Coleosporium, but concerning this it is, I think, permissible to withhold one's opinion till further evidence is adduced. Endophyllum is a curious genus, in which the spores are produced in chains, and surrounded by a pseudo-peridium, exactly as in Œcidium, but nevertheless germinate like those of a Puccinia, with the formation of a promycelium and small round sporidia. It is found embedded in the leaves of *Euphorbia amygdaloides* and species of Sempervivum and Sedum. Dr. B. White has described (in "Scottish Nat.," iv., p. 163) a new genus, Milesia, allied to Endophyllum, found in the leaves of *Polypodium vulgare*.

Of the genera included in the Handbook, which are not mentioned in the foregoing list (p. 28), Xenodochus is absorbed in Phragmidium (a change hardly to be recommended); Tilletia, Ustilago, Urocystis, Thecaphora, and Tuburcinia are placed in the Ustilagineæ; Cystopus is removed to the Peronosporeæ; Trichobasis is merely a synonym of Uredo; and Graphiola is not truly British. A number of species, however, at present imperfectly known, must be arranged provisionally under the pseudo-genera Uredo, Cæoma, and Œcidium; such are *Uredo agrimoniæ eupatoriæ*, *U. hydrocotyles*, *U. quercus*, *Cæoma mercurialis perennis*, *Œcidium quadrifidum*, *Œ. clematidis*, and others, among our British species.

Meaning of the Œcidium Stage.

There is one point which strikes an attentive observer of the foregoing phenomena very forcibly; I mean, the apparent uselessness of the œcidium-stage in the life-history of a Uredinous fungus. Why should a puccinia-spore generate an Œcidium? Why not produce the Uredo at once? Some Puccinias indeed have no Œcidium, as *P. malvacearum*, but why not all? This is a question upon which I have seen few attempts made to throw any light. We can see the object of the Uredo and the Puccinia, but not of the Œcidium. There is only one glimmer in the darkness, and that will be introduced by the point to which I wish now to draw attention. I believe that in the life-history of most plants there must occur, more or less frequently, a process akin to the fertilisation of the phanerogams. There must be that mysterious commingling of the contents of two distinct cells, from which animal and vegetable species alike derive a renewed lease of life. Many facts point to the conclusion that a species which reproduces itself only by budding has a tendency to degenerate continually, and finally to become extinct. It is true that there are apparent (or real) exceptions to this law, where a species maintains itself, so far as we

* See "Grevillea," iii., p. 124.

know, by purely asexual means. But it seems to me that we lose the significance of a whole body of facts if we refuse to believe that the law is as I have said. We cannot forget in how many instances the presence of an act of fertilisation has been detected where it was formerly unknown, as in the Fucaceæ or Bladder-wracks of our sea-coasts, and in Volvox, the Desmidieæ, the Diatomaceæ, and other Algæ, not to speak of instances now so well known as the Ferns and the Mosses. There are now several groups of Fungi in which a true reproductive process is known to occur, as in the Mucorini, the Peronosporeæ, the Saprolegnieæ, and some of the Ascomycetes. We must remember that the reproductive process is one of the chief means, on the Darwinian theory, by which new species are produced: a group of organisms, which has entirely lost traces of a gamogenetic act, has thereby reduced itself to this difficulty—that as the existing species disappear, under the influence of competition, it can form no others of a more or less divergent character to suit the changing circumstances, and so has doomed itself to a sure, though lingering, death. It is true that, if it avail itself of the sexual act to produce invigorated descendants, it perpetuates itself under a changing form, which finally becomes what we call a distinct species; but still it does perpetuate itself, which is the main point. I believe that the only cases, in which it may be conjectured from our present knowledge, that gamogenesis is absent, are found in organisms which inhabit water: such are, perhaps, the Oscillatorieæ. But it is conceivable that most species which live in water are not subject to such changing conditions, do not require therefore so great a power of adaptation to circumstances as do those which live in the air. However this may be, a family of plants so large and so varied as the Fungi are must have formerly possessed the means of sexual reproduction, and probably in great part still retains it: in no other way can the existence of numerous and closely-related species be accounted for.

Now, if we were to look for a process of fertilisation in our leaf-fungi, where should we probably expect it to occur? Analogy will help us to answer this question. A flowering plant usually produces seed when the vigour of its growth is ceasing. I need only remind you that a rapidly-growing fruit-tree, in which a superabundance of sap is present, seldom fruits; and that a gardener who wishes to make a geranium flower stints its supply of water. It is true that there is a seeming exception to this law in the case of trees which flower in spring, before the leaves are out; the common Coltsfoot (*Tussilago*) would also seem to contradict the rule; but really they obey it. In all these cases the buds which are to develop into the flowers are formed at the *close* of growth in autumn and only wait till spring to complete their development. Applying these considerations to the Uredineæ, we are naturally led to look for the sexual process in the production either of the Puccinia or of the Œcidium. The probability is vastly in favour of the latter, viz: that fertilisation occurs in the mycelium produced by the germination of the sporidia, and that the Œcidium is the product thereof. Curiously enough, it is here that we meet with the only known organs which suggest a sexual process in the Uredineæ, the *spermogones*. These are minute flask-shaped bodies, which are produced on the same leaf that bears the Œcidium, usually a little earlier, sometimes on the opposite side of the leaf, sometimes among the Œcidia themselves. They contain an enormous number of small oblong cells, which are perfectly transparent, and enveloped in a mucous secretion. These were called *spermatia*, from a suspicion that they represent the male element in a reproductive act; this suspicion was strengthened by the difficulty of inducing them to germinate. Recently, however, it is said that a well-known French biologist has succeeded in compelling them to germinate, and thus produce a mycelium; but remembering how a pollen-grain may be said to germinate, in a sense, when it sends out a pollen-tube, we may be excused for waiting for further investigation before we consider such a statement a bar to the truth of the supposed function of the spermatia. It is at least probable, both from their size and character, their vast numbers and their mode and time of growth, that these bodies are the male organs, and that the female organs are produced and fertilised on the spot where the Œcidia are subsequently formed. The Œcidia would then be the true fruit of the fungus. The whole subject is at present wrapped in mystery. I often think how the next generation, after clearing up this and many similar difficulties, will look down upon us as a crowd of bunglers, who did not know how to use our microscopes. The subject is one of great interest to us from our present point of view, because, if the reasoning just given should turn out to represent the facts correctly, the whole scheme of arrangement of these fungi must be remodelled. The Œcidium-stage, and not the Puccinia-stage, would then be the typical one, and our classification must be founded upon that basis.

It may be asked whether, under these circumstances, it is right to continue to give names to these stages of growth, as if they were independent species, to talk, *e.g.*, of *Œcidium violæ* as well as of *Puccinia violarum*. To this question the answer must, at present, be in the affirmative; it is only when our knowledge is approximately complete that we shall be able to decide finally what arrangement should be adopted. When we consider that many of these fungi are often met with under one form only, we must admit the necessity of having a provisional name for that form. At the same time it will be possible to arrange the various stages of species, so far as they are known, together, and not, as now, on widely separated pages; and this scheme would also meet the requirements of those who merely want to discover the names of their finds, if a little typographical ingenuity be exercised in placing them so that one may be able to glance through all the œcidium-forms, for instance, without reading the descriptions of the other stages.

Finally, I may remind you that I promised to treat of "Nomad

Fungi," and ask you whether the title is not merited by those species, of which one begins its existence upon the Dock, and terminates it upon the Reed; another pitches its tent upon the Nettle, and transfers it to the Sedge; a third on the Coltsfoot, from which it passes to the Meadow Grass; a fourth travels from the Wood Spurge to the Common Pea; a fifth from the Fleabane to the Rush; and a sixth from the Barberry to the Corn.

ON A DRAGON FLY.

By Silvanus Wilkins.

Read before the Society, November 22, 1881.

In April last I had the pleasure to win your kind attention to a short paper on *Fish Rearing*, written in plain purpose to show that some practical work can be done with little or no cruelty or waste of life if your tools are of the right sort.

I mentioned at the reading that I had been led to do this to refute a statement I had seen "that there was nothing to interest the naturalist in the Midlands, and that it was a district to be shunned." The Stickleback, I hope, furnished to my companions a fair instance of fish life-history, in, it would be thought, the least likely of regions.

I venture to fill up the allotted twenty minutes and space of five or six pages this time on *Insect Life*, limiting it, as before, to what anyone with patience may see or do, and as I am mildly indignant at the above aspersion against the Black Country as a libel, it suggests itself to me to choose the Libellulina for our notice, because it so happens that this is quite as good a spot for watching the habits of the Dragon-fly as it was for the fish, and perhaps that insect, having all the parts in perfection that constitute a type insect, offers, take it for all in all, from the egg to the imago, as quaint a series of pictures as can be found in any one creature (excepting man, of course).

Space will limit me to mode of capture and life-habit mostly, and a full description of the mask apparatus, with its double joints and hinges, seems better suited to a mechanical magazine than one on natural history; but of its form and anatomy an excellent and full account can be found in Kirby and Spence's or Westwood's Entomology.

The larvæ can be caught by sweeping against and through the vegetation round the sides of pools with a strong net, or they may be found in hollow pieces of old wood, into which they will crawl and hide if placed in the shallows near the side; another good plan is to shovel up smartly some of the surface soil at the base of the rushes, etc., and throw it on the sloping bank, then with a fine rose-nozzle of a watering pot, wash out the mud steadily so that it drains back, when the chances are you will see one of the larvæ.

This strange being seems as ill-born as Caliban, and is the veriest dragon from the beginning, for it would appear that it is the nature of the embryo—of this alone of all embryos—to have the trick of always taking an obverse position in the egg.

The respiration might not incorrectly, I think, be called a perspiration only, and contains the principle of a patent to beat the screw propeller, if one only knew how to apply it, and one is set guessing if it is the inversion in the egg which has turned about the action of the breathing so curiously. I hope this order of being is not fated to be evil for ever because it had not the benefit of proper inspiration at first.

As for the larva, it is more masked or truly larva-like than any other I know. Its form, in the parts of head, trunk, and abdomen, seems an ensemble preserved to us in microed size, typical of life on the malignant side that became dominant and monstrous through the three great geological periods. In its jaws it has the faculty for snapping possessed by the huge mollusc; in its neck and body segments the writhing of the saurian; in its legs the grip of the cephalopod, and in the abdomen the vices that held to the mammalian.

In habit it has the stealth of a cat. It can prowl like a wolf, snatch like a monkey, snap like a crocodile, and bite like a bull-dog.

In fact, in both its states of water and air it can do everything wicked, except the one thing it popularly is supposed to do best—namely, sting, and it has a mean way of rarely seizing anything larger or stronger than itself, choosing small fry and never tackling big folk.

A caddis-worm, after the covering is cut off, makes a good supper for a dragon-fly larva; but it is careful to seize the caddis in the rear of the head for fear it would seem of the powerful mouth with which the latter is armed. These greedy creatures will also take an ordinary garden worm nearly every morning. One about their own length suits them best, for if the worm be too long so that one end of it can get a hold or purchase between two stones, it will draw away, dragging the larva until its large round jutting eyes meet the obstruction, and the enemy is peeled off to his amaze, if not to his damage. When a worm disappears in this way the larvæ will sometimes stay watching the opening for a long time with their heads turned down, and a little on one side, like a dog at a rat hole.

The snatch of their jaw-forceps is so quick it takes good eyesight to see it; but a worm by its quickened movements when dropped into the water in front of them often causes thém to miss once or twice, and the action repeated gives a good opportunity for catching sight of it. The worm can be lowered and dangled in front of them, held by just one turn of a fine silk thread, out of which they will drag it. They will gorge a worm their own length in two or three minutes, during which time the movement up and down of the abdomen in breathing is very marked, as if heaving to suck the food in. The gorging is helped by the nippers, which take a fresh hold higher up before each piece is bitten off by the jaws and passed into the gullet.

Although they will tackle a snail at times when hungry, with, however, the risk of being partly drawn into the mouth of the shell and held there for a time, they will, very strangely, let a snail slowly crawl along and over their body without starting away, as they mostly do when touched by other moving things in the water. I have thought that perhaps the sliding movement of the snail over them may groom or shampoo them, as it were, and clean off parasites and other attached things.

In ordinary course, when no prey is in sight, their crawling motion is very slow, as if their watery home made them stiff and rheumatic; but this is only their artfulness, for they no sooner sight any choice food in motion at a short distance than their slow action is changed to one of great alertness. They raise their head and forepart of their body by planting their first pair of legs like a carriage horse, and the action of the neck becomes grand, subtle, and free, as that of a snake or lizard, for a moment or two. They then advance like a cat after a bird, until within half an inch of their prey, when out shoot the jaw-calipers, and the object is seized. They will, however, if surprised with enticing prey, such as a young minnow, swim after it in rapid jerks, and make a dash at it as it moves; but they appear to think twice in view of the spines of the Stickleback, and conclude him to be sour.

They are very careful, after a meal, to clean their face, removing all particles of skin or harder stuff that has not been sucked in, and which has got attached to their teeth and lips. This they do with their jaw-forceps, and these they then sweep clean with their fore-legs after the manner of a fly or a young rabbit cleaning his whiskers.

By means of its gluttony the larva stores up an energy for use in wing power in its aerial state more marvellous that Faure's cell of condensed electrical force, but only to be more dragonian. I notice the clergy explain this voracity by kindly calling it the balance of nature. Angels, however, are not perhaps so pink as they are painted, and if evil be that which is out of harmony with the laws of man's nature, one is bound to affirm at least in the Dragon-flies' favour that their ways do no known harm to him or his.

They are fond of a stick about a half-inch square in the aquarium to cling to, round which they will play bo-peep with you as you go near, slipping from side to side out of sight as you show yourself, but as if partly tamed with the regular feeding. They also prefer porous tile to smooth stones to hide under, as they can cling more easily to it. They refuse their food a day or two before each moult of skin, and the time of fasting is increased to about a week or ten days, just before they make the final change to the imago. During this period they climb up the stick or any stem to the surface, so as to expose their mouth and eyes slightly, and it is, I think, during this stage that the altered mode to breathing the common air is undergone. After this amphibious interval, the first hot day is chosen by them for the change to the higher life, the sight of which ought to be almost enough to awaken faith in an agnostic.

I do not know how many times altogether they moult from the egg to the imago, but I have seen that they shed the skin four times during the last six months before the imago comes out. Throughout the whole time and process of the larval state it is very necessary to keep the water well aerated by balanced vegetation or a syringe.

We will, if you please, resume our loafing at the old centre, namely, Edwards' Pools at Bilston, and need not go far to see all we want, as they can always be found here in summer in the winged state.

Choose the early hours of a fine day in July or August for a stroll round the borders of the pools. Near the edges or corners where the reeds, rushes, and flags are growing, you may soon find out by the numbers flying to and fro where these dragon-flies are colonised.

It adds much to your chances of observing if you first mark out where they are located, for they are shy, and as symbolised by the large development of eye-faculty they are correspondingly swift in flight; but the kind chiefly found here—the *Agrion*—is, luckily for learners, the least active. The eye of this species seems a millenocular stereoscope, and is a wonder under the magnifier, looking like the round knob of the stopper of a glass decanter cut into ten thousand facets, each one of which is said to receive a picture of the objects around. What can the optic lobe of its microscopic brain be like? This is a fine point. The best mode I know of preserving specimens of this is never to catch any, but to leave them to enjoy their existence. Some procure them to cure them, but it is a ragged piece of business at the best, and certainly is no longer necessary for anyone who will become a member of the Birmingham Natural History Society, with access to the beautiful works on their form and colour to be found in its library.

Don't make any attempt to chase or run them down, but seating yourself very gently, where you can look about and have them for a yard or two within reach, you leave them to their sports. They will hawk around, but never go far afield, and by remaining in one spot you are more likely to catch sight of a larva, like a Captain Boyton, or a diver in his water-tight dress, coming up out of the water on to the vegetation. The male in the winged form rather bears out the rule of the gayer clothing, but mostly in primitive or simple colour, and is of the two sexes a little more active. The females settle more frequently on the vegetation.

Very soon you will descry a male on the wing, which you keep in your eye as far as the range will admit without turning your head, on the look out for a partner. This is done with an *elan* that a Frenchman might admire, seizing her with such force, that sometimes, like a harrier overrunning his game, they topple over together. This brings their wings into such juxtaposition that their flight is impeded, and after a time they settle. Of about 200 sorts in England, nearly a tithe may be found here, mostly with blue about them, and to see this action of seizure you cannot resist the simile of a policeman chasing and securing a runaway.

The plan to keep them captured until the deposit of the eggs begins is this: For catching the Stickleback without hurt, the best plan is the open silk thread net which I suggested ("Midland Naturalist," 1881, page 110). In this case, to make your work easy, you have ready a glass shade about seven inches across and ten inches high, such as is used to cover small chimney ornaments. Let it be white and thin, with, if possible, a knob at the top, attached to about a foot of fine wire or thread so as to hang it from the stout joint of a fishing rod or a stick about five feet long. If it hasn't a knob you have to fix a lashing, which is awkward. You also have ready a thin piece of cork or light wood about nine or ten inches across. This is to slip under to stand the shade upon. Keep these and a pair of scissors all ready within reach.

Having beforehand chosen a good spot and placed yourself where you may sight them, which you may soon do should the morning be a hot one, you select those closest to the edge of the land or just over it, and quietly bring round with your left hand the glass shade somewhat above them, and gently lower it over them, then slipping the piece of cork under it as a base, and having the scissors handy to cut any stems in the glass which you leave there for them to cling to. The open mesh of the net puzzles the fish, and you will find that the transparency of the glass, in a similar way, puzzles the insect, so that if it be carefully managed they will not be disturbed, and you have them secured in a crystal palace.

This kind of glass shade, perforated with a hole through the knob at the top to let the air escape, can sometimes be used for securing water specimens by lowering it over them into the water. By standing your cork base with your glass shade upon it in the centre of a handkerchief, and tying the four corners over the top, you have a capital mode of sheepishly carrying your capture home.

I assume, as before, that your aquarium is well prepared; but the vegetation should be such that there may be several stems or floating leaves on the surface. The more light and sun they get the better; so if you can work, as I was able to do, at a tank in a conservatory (Hawkesford's) it is a great help. Before removing the glass shade and setting the cork afloat with your capture upon it, you need some kind of cover inverted over the aquarium. If you have the Agrion this may be a frame cover of leno lace, but if you have caught the larger kind they will gnaw through this, so it is best to invert another glass aquarium over them, turning in with them a good supply of flies, gnats, or spiders, which they will seize as they come across them, if they have not been hurt in transshipment. The full feeding is very necessary both in the larval and imago state.

As it is well, however, to keep as near to natural conditions as possible, your best plan, I think, is this: Having left them on the pond side for an hour or two, you raise the glass shade and set the captives free. If deftly done it is likely the gentleman will take part in assisting his lady in the duty of egg depositing, which begins about mid-day and goes on throughout the afternoon. Suspending her by his claspers round her neck, he sails away and brings her poised a few inches over the water, now and again lowering her with a sweeping stroke or dash down to the surface, she at the same moment releasing an egg at each dip. You may see this done to the number of twenty times or more by any one pair. There is an easy dancing action in this, which leads one to think that it is a great help to her in her efforts.

Should, however, the lady be left to herself, she no less faithfully fulfils her duty to the future offspring she will never see; but it is manifestly a work of greater labour alone. She then alights on the stems or leaves of plants near the surface, and you may see her bend her long body into a curve until the ovipositor touches the plant, and the eggs are laid there, one at a time, and may be found upon it. As the leaf decays it carries them to the bottom.

Most of the names of this genus imply a malignant power which is not inapt, and as I had my quirk last time at nomenclature I should not wish any scientist to arch his eyebrow again at me. I hope I regard all true science as the light of life and its laws.

It is more than half a score years since my spare time and walks were given to observing in this district, but as I pass through it by train or tram I can see from the windows many of the old haunts of hydra and entozoa, insect and fish, that I am sure would well repay the visit of naturalists any fine day in summer.

Mr. M'Lennan, in his work on primitive marriage by theft or force, traces the ceremonies and modes of seizure among the early traditions of nearly every race. I fancy, however, he cannot well begin or stop at primitive man or even vertebrates, but may carry the traces far beyond all record, and spell out an exemplification of early wife capture in the habits of the Dragon-fly.

Haeckel, Spencer, Darwin, Sir John Lubbock, Grant Allen, and others try to show us by means of Biology, that every animal has been slowly moulded through a wonderful series of metamorphoses into its existing shape by surrounding conditions, and that each bears in its parts or form the traces, when we can read them, of its development or evolution, and that mankind, step by step, sums up into himself, more or less, along an endless line of ancestors, all the antecedent life of a small trifle of eons of old times.

We may ask ourselves what kind of life has each race of man for the most part summed up into itself, and how much of the Dragon, for instance, has evolved or devolved for each of us. The manners, habits, and customs of a race, it has been suggested, are the key to this specialisation, and that running through the forms of lower life preserved to us we see the vestiges of all the earlier stages and changes.

If you then will throw your fancy into the scene among the Dragon-flies you may not be mistaken in finding many of the phases of wife capture after the old order of things brought down to our own days, as M'Lennan describes them.

Happily, with us, sweethearting has evolved from might into manners, from capture into courtesy, as Coventry Patmore depicts in the "Angel in the House":—

"Lo! how the woman once was woo'd—
Forth leapt the savage from his lair
And felled her! And to nuptials rude
He dragged her, bleeding, by the hair.
From that to Chloe's dainty wiles
And Portia's dignified consent—
What distance! But these Pagan styles,
How far below Time's fair intent.
* * * * *
Shall love where last I left him halt?
Nay; none can fancy or foresee
To how strange bliss may time exalt
This nursling of civility."

A VISIT TO GLEN CLOVA AND CALLATER.

BY G. CLARIDGE DRUCE, F.L.S.

Read before the Society December 19th, 1882.

To the Botanist the name Clova is one of the most interesting among the many rich and fertile places which still remain in Britain, and I derived such pleasure from a recent visit, that I thought it probable some of the members of this Society interested in Botany might care to hear the results of a few days' botanising in a district discovered, I may say, by Don, a florist of Forfar, who began a rough and hard life's labour by an apprenticeship to a watchmaker, afterwards removing to Glasgow, where he obtained a situation as assistant to the Professor of Botany. He then went to Edinburgh, where he eventually made the acquaintance of Sir James E. Smith, who frequently quotes him in his "English Botany;" but, as with Murchison's friendship with Robert Dick, no pecuniary advantage accrued to Don from it.

Don returned to Forfar and obtained a small piece of ground, which he turned into a botanic garden, and in which he grew a great collection of the rarer alpine plants: this garden he called Dovehill. To obtain the plants he made long excursions over the country, his favourite ground being the hills of Clova, and to these, some thirty miles from Forfar, he would walk with no provisions besides some oatmeal or bread and cheese, and no shelter save his plaid, loaded with his paper and bag.

For living plants he would ransack the rocky glens and bleak moors and spongy morasses, adding to our British flora that most lovely willow *Salix lanata*, with its leaves covered with golden-coloured down, the pretty little pink-flowered *Lychnis alpina* on Culrannoch, the graceful alpine Cotton Grass at Restennet, the rare grass *Calamagrostis stricta*, and *Caltha radicans*, near Carse, which, since 1790, when he found it, had disappeared, till recently it has been refound in the vicinity by my friend Mr. Peter Graham, who kindly showed it me this summer.

Besides the above, Don added a willow, *Salix Doniana*, about which there is some doubt as to its indigenity. With the mosses he was almost equally fortunate, the little moss *Gymnostomum Donianum*, Sm., being by found him, I am informed, when he was only fifteen years old. *Splachnum tenue*, *S. ampullaceum*, *Didymodon inclinatus*, *Weissia nigrita*, *Bryum trichodes*, and other mosses being added to the Forfarshire flora through his industry.

A life of privation and hard work at length told upon his constitution, and a severe cold, caught on one of his excursions, turned to a putrid sore throat, to which he eventually succumbed, leaving his family in extreme poverty. From the enormous amount he collected, and the few facilities he had for keeping his specimens in order, there is no doubt that occasional mistakes were made in his records; but I do not think he deserves the great contempt which some "arm-chair" botanists, such as Arnott, cast wholesale upon him, since several plants recorded by him and long treated as errors have eventually been rediscovered: for instance, *Hierochloe borealis* was said by Don to be found in Glen Cally,—now that glen, or at any rate the head of it (the least likely part), has been searched unsuccessfully; but then possibly the search had been made too late in the year. At any rate, the *Hierochloe* was treated as one of Don's reputed discoveries, till another poor working botanist, Robert Dick (since rendered famous by Smiles), discovered it near Thurso, thus showing there was no great improbability in the Glen Cally record: and further search may rediscover some of the other plants which now figure only in the list of "ambiguities" or "impositions" in our British list. It is said that his Moss records have all since been verified.

When I started for Clova it was just after revelling in the sylvan glades and sphagnum bogs of the New Forest, gathering in the one the splendid crimson spikes of *Gladiolus*, and the delicately lovely flowers of *Melittis*, while in the other the tiny Orchis *Malaxis*, the rare *Rhynchospora fusca*, the *Isnardia*, and other rarities offered a great contrast to the *Gentiana verna*, *Potentilla fruticosa*, *Polygala uliginosa*, *Alsine stricta*, *Helianthemum vineale*, and *Viola arenaria* of that strange sugar limestone district of Teesdale, which had tempted me to linger on my northward journey, and perhaps dulled my appreciation for all but he rarer plants; yet, despite these rich treasures, I longed to get to the little inn at Clova, where it is best to bespeak rooms a week previously, and also to obtain a pass from the owner of Glen Dole—Mr. Gurney, of Norwich—a permission obtainable, I am told, not later than June, since the Dole is unfortunately now a deer forest, and the generosity sometimes shown to botanists by landowners is not, I am afraid, conspicuously developed in the present owner of the Dole.

After leaving the train at Kirriemuir, sixteen miles south of Clova, a conveyance was hired, and a pleasant drive it was up to the kirktown of Clova. Once there, the first walk was by the river side to gather *Carex aquatilis* var. *Watsoni*, which occurs about half-a-mile from the inn. Turning eastwards from the river the road is soon met with, fringed here with that lovely Umbellifera *Meum athamanticum*, while the turf is besprinkled, as in Teesdale, with the pretty *Viola lutea*, varying from the richest purple to the palest yellow. A short walk brings one to the little stream that flows out of Loch Wharral, and following up this, at an altitude of about 2,000 feet, the little Highland loch appears, bordered on the north-east side by steep rocky corries, while its south side slopes into green woodlands. Down the corrie a little stream runs into the lake, and above this may be gathered *Saxifraga stellaris*, *Epilobium alpinum*, *Juncus triglumis*, *Hieracium anglicum*, *Veronica alpina*, and the foliage, if not the flower, of that rare grass *Alopecurus alpinus*.

From the moorland (altitude 2,500 feet) a short walk brings one to the top of the Green Hill (2,837 feet), whence a good view of the East

Forfar Hills may be had. A descent from this of 800 feet, in a northerly direction, brings one to Loch Brandy, where, on skirting the south side, quantities of the cloudberry *Rubus Chamæmorus*, in flower or fruit, will be met with, as also of *Arbutus uva ursi*, and *Empetrum nigrum*. In the north-west corner of the lake grow *Subularia aquatica*, *Nitella opaca*, *Isoëtes*, *Lobelia Dortmanni* and a variety of *Ranunculus Flammula* which flowers under water; this lake, like Wharral, has the same high cliffs on the north and east, and on the stony débris may be found *Lycopodium annotinum*, and a few plants of *Aspidium Lonchitis* still survive the depredations of Dundee excursionists, to whom this loch is the Mecca of their pilgrimage. Higher up the corrie occur *Hieracium argenteum*, *H. pallidum*, *H. eximium*, *H. melanocephalum*, and *Rhodiola*, while in the water-course some fine plants of *Cerastium alpinum* may be gathered. On the moorland near *Lycopodium complanatum*, recently added to the British flora, was obtained. On attaining the top of the corrie, the summit of the Snub is reached (about 2,500 feet), here covered with *Loiseleuria procumbens*. The Snub itself is partially separated from the corrie by a narrow rift a few feet wide and about seventy deep, of recent origin, which the yearly frosts widen perceptibly. Looking north-east Lochnagar may be plainly seen, while the western sky is filled up with the summit of the Bassies and the Driesh, which separate Glen Clova from Glen Prosen. Northwards is the fine front of Craig Mellon, north-westward of which is the entrance to the Dole, the north-eastward road leading up to Glen Muick or Bachnagairn. A short walk takes one to Ben Reda, whence the descent may be made into the glen. On one of the many ruined shielings (there being ninety-four in this glen alone) *Gnaphalium margaritaceum* occurred, and ascending up the most southward turn from Loch Brandy a strange variety of *Gentiana campestris* was gathered, with *Habenaria albida*, *Polygonum viviparum* and *Veronica humifusa*.

The next day was of course spent in the Dole. I began my work at Craig Maid, a high mass of rocks (about 2,250 feet) on the west side of the Dole, about eight miles from the hotel, and on this historic rock, magnificent in outline, a rich field for work presented itself: steep rocky cliffs with grassy ledges, on whose rich micaceous soil grew at some considerable height the rare *Erigeron alpinus*, the lovely perishable flower of *Dryas octopetala*, the beautiful *Veronica saxatilis*, the rare sedge *Carex rupestris*, and *Gnaphalium norvegicum*. Still higher occurs *Mulgedium alpinum*; and here too Professor Graham first found *Astragalus alpinus* in Britain. By the stream sides grew *Cerastium alpestre*, *Juncus biglumis*, *Hieracium Lawsoni*, and *H. calenduliflorum*; and now again on the ledges, on one occasion so narrow that progress could only be made crab-like (sideways) on one's knees, we gather *Carex Leesii*, *Hieracium eximium*, *Carex atrata*, *Salix reticulata*, etc. All about the Dole were splendid fronds of *Aspidium Lonchitis* varying from two inches to two feet in length, while *Salix Lapponum*, *S. petræa*, *S. Andersoniana*, *Gnaphalium supinum*, *G. sylvaticum* var. *alpestre*, *Juncus trifidus*, and *Carex atrata* were again and again met with. Coming to Craig Rennet, at about

2,000 feet a quantity of *Linnæa borealis* was met with in fragrant flower, growing near that lovely moss *H. crista-castrensis*. Ascending again on to steep ledges *Oxytropis campestris* was gathered, in its only British locality, and close by this that rare British fern *Woodsia hyperborea*, for which so many botanists have hazarded life or limb. Close by grew *Avena alpina*, *Aira alpina*, *Aira brevifolia*, and other rare alpine plants; then, searching the rocks of Craig Rennet, which form the north boundary of Glen Phee (itself a western prolongation of the Dole), at the head of which a burn comes sprawling down some three or four hundred feet, and climbing up the wet shelving rocks on the south side of the burn, another series of alpines was gathered, including the sweet heliotrope scented *Saussurea*, white and pink flowered *Saxifraga oppositifolia*, large flowered *S. hypnoides* and *S. sponhemica*, *Epilobium alsinifolium* and *E. anagallidifolium*, *Cochlearia alpina*, sweet-scented *Pyrola rotundifolia*, large plants of *Asplenium viride*, *Pseudathyrium alpestre*, *Salix herbacea*, that smallest British shrub, *S. reticulata*, with abundant capsules, *S. Myrsinites*, *S. procumbens*, *S. arbutifolia*, *S. Stuartiana*, *Poa alpina*, *Vaccinium uliginosum*, mimicking the willows in habit (here I saw it for the first time in flower), *Sagina saxatilis*, *Silene acaulis* var. *alba*, *Carex vaginata*, *C. rigida*, *C. capillaris*, *C. flava*, *C. pallescens*, large *C. atrata*, *Rhodiola* in profusion, *Sibbaldia* and *Rubus saxatilis*, while on the moorland (above 2,600 feet) *Carex aquatilis*, *C. vitilis*, *Caltha minor*, *Tofieldia*, etc., occurred; in fact, of all the plants recorded for the Dole and Phee, I only missed *Carex Grahami*.

Another day was occupied in walking from the kirktown up Glen Clova to Braedownie, turning eastward by Craig Mellon, and on to Bachnagairn shooting lodge (1,500 feet). Ascending moorland to north-west up to Loch Esk (2,500 feet), thence ascending to western ridge (2,750 feet), and descending to the White Water, I found *Phleum alpinum*, *Caltha minor*, *Carex aquatilis*, *C. vitilis*, etc. Keep by the side of White Water till it reaches the base of Tolmount, ascend it (3,140 feet), and then stretching out before is the fine Glen Callater, Lochnagar, and the Broad Cairn on the east, Carn-y-Glasha and Glas Mheal to the west, while northwards, over Braemar, rise the Aberdeenshire Alps, Ben Avon, etc., with the snow-fields shining on their southern slopes, still unmelted by the August sun. Descending the cliffs of Tolmount (about 500 feet), and then keeping on the west side of Glen Callater, a gathering almost as rich as from the Dole was made, a list of which I will not now detail, but simply enumerate some of the special finds:—*Salix lanata*, in magnificent condition, overhung the steep rock of a small waterfall (at about 2,500 feet), and near this a single plant of *Mulgedium alpinum*. Here too *Carex vaginata*, and *C. Leesii*, the latter only an acute-glumed variety of *pilulifera*, with *Cerastium alpestre* were gathered, *Poa Balfourii*, *Aira alpina*, and *Juncus castaneus*, the latter nine inches high, *J. biglumis*, etc., were found. Descending to Loch Callater (1,600 feet) *Carex ampullacea*, *Subularia*, *Isoëtes*, *Callitriche autumnalis*, etc., were gathered.

The next day was employed in walking up Glen Callater on the west side of the loch, where the rich profusion of *Saxifraga aïzoides* and strongly stunted *Veronica Beccabunga* were admired; then ascending Tolmount (3,140 feet), descend to White Water, where *Cornus suecica* was gathered, ascend Tom-y-Buide (3,400 feet), descend to moorland (2,750 feet), and walk across to Little Culrannoch (3,200 feet). Here there was a great profusion of *Lychnis alpina* in splendid flower, growing with *Armeria duriuscula*, *Cochlearia alpina*, and *Cerastium alpestre*. A fine view was had of Glen Caness and Glen Caenlochan, the white quartz veins at its head marking the locality of *Gentiana nivalis*. Descending to the White Water by the Fenlah burn *Carex rariflora* was gathered, and then a rough and toilsome journey was made up the valley of the White Water to Carn-y-Glasha (3,484 feet), and thence to the corrie of Loch Ceander. From the rocks above a fine view was had of the east side of Glen Callater, the polished rocks showing the glacial friction most plainly. By the stream above the corrie grew *Alopecurus alpinus*, *Phleum alpinum*, *Equisetum nudum*, etc., and in the corrie itself (from 2,600 down to 2,000 feet) a rich gathering was again made. In addition to the plants before mentioned occurred *Hieracium chrysanthum*, *H. cæsium*, *H. nigrescens*, *Carex rupestris*, *Pseudathyrium alpestre*, *Salix glauca*, *Carex vaginata*, *Polygala grandiflora*, etc.,; and then down came the rain (which had been threatening all day) in thick sheets, while the mist came rolling over the cliffs, shutting out rock after rock from vision, till the descent became risky. But at last, one reached the boggy ground at the foot of Loch Ceander, where *Carex pauciflora* was gathered, and then a squashy walk was made down to Braemar with little besides *Nitella opaca*, *Chara fragilis*, *Pyrola rotundifolia*, *and Listera cordata* to cheer the way.

The following day proved but little better, heavy clouds hanging over the mountains, rendering the glen still more gloomy; but still Lochnagar had to be ascended, the intention being to descend by the great precipice to the lake and thence to Balmoral and Ballater. Near Braemar *Hieracium prenanthoides*, *H. murorum*, *Salix phylicifolia*, *Campanula rotundifolia* var. *montana* were gathered. By Loch Phadrig (2,000 feet) is a plentiful growth of *Betula nana*, and on the ascent to Lochnagar *Hieracium chrysanthum*, and *Trientalis Europæa*, may be gathered. On the moorland (3,250 feet) overlooking Loch Dhu is the locality for *Carex rariflora* and *C. lagopina*, but the latter this time I could not see, for here the clouds came down so thick as to render anything beyond ten yards invisible, distorting and magnifying objects till a poor unforunate sheep became the size of a deer. Here in a ravine *underneath* a snow wreath I sat sheltered from the rain for three hours, and then was obliged to retrace my steps to Braemar.

The foregoing will show what a rich spoil of plants may be gathered even in indifferent weather, and as I have already exceeded the space I originally intended filling, I am obliged to omit any account of the plants gathered at Loch Park, Deeside, and the sands of Barry, and of my doings during a most interesting day occupied in dredging Lochs Rescobie and Balgavies, and botanising in the bog of Restennet.

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CONTENTS.

TRANSACTIONS.

ADDRESS OF THE PRESIDENT,

Mr. T. H. WALLER, B.A., B.Sc.Lond.

DELIVERED AT THE

ADJOURNED ANNUAL MEETING,

MARCH 4th, 1884.

Ladies and Gentlemen,

I find myself called upon to deliver an address, although your flattering re-election of me to the honour of the Presidency of the Society has made my retiring only a nominal performance, and might have been supposed to have obviated the necessity of your listening to anything from me to-night.

As so many Presidents have done, I have to acknowledge, with gratitude, the kind consideration and assistance which I have received in the office, with the duties of which I was so completely unfamiliar, from the Committee and the members generally, and remember with emotion that since the Annual Meeting one to whom we then looked for the continuance during this year of the kindly and courteous aid as Curator, which he has afforded us in the past, has been removed from among us. In Mr. R. M. Lloyd's devotion to the duties he had undertaken we have each of us a lesson. Ever at his post at our meetings, as these recur we shall be constantly reminded of him, and shall miss the assistance he was always so ready to give us.

From the change which we have recently made in the subscription to the Society we all, I believe, look for the means of increasing its usefulness to the members in the study of Natural History, and of spreading more widely among them the results attained by workers in other Societies of the Union.

Although there are probably a certain number who either do not approve of the change or doubt its expediency, I hope it may be found that defections from our ranks on this account will be few, and that, among the great body of the members, the careful consideration which has been given to the objects and means of the Society, in consequence of the alterations made, has produced a stirring-up of activity, and an increase of zeal for the purposes of study and mutual help, for which we are associated together.

An old proverb speaks of the advisability of the cobbler sticking to his last, and therefore I propose to limit my remarks to a sketch of some of the subjects relating to Geology which have given an interest to the past year. Into the details of Stratigraphical Geology I cannot enter, and Palæontology I cannot touch, but must confine myself to points which have a bearing on the Chemical and Microscopic side of the science, as being those with which I am personally more conversant.

The two great *phenomena* of the year may both be said to be volcanic, and, therefore, suitable for some mention. The calamitous earthquake which desolated the fair island of Ischia last summer reduced, almost instantaneously, a great part of the buildings on it to ruins, burying in them a multitude of the unfortunate inhabitants and visitors, a full enumeration of whom is, and probably ever will be, quite unattainable, since in many cases the fallen masonry was too massive to be removed, and remains the tomb of unknown numbers overwhelmed by its ruin.

Those who attended our opening meeting in January, or who were present at the Conversazione of the Midland Institute, will remember the fine series of photographs of the results of the earthquake exhibited by Mr. Johnstone Lavis, and the diagrams which accompanied them showing the theoretical deductions from the observed facts.

The history of earthquakes, on the whole, points decidedly to what we may call a volcanic origin, though here we may seem to be explaining one name by another as little understood.

Still, many observations prove a close relation between volcanoes and earthquakes. I need not cite many examples, but will merely recall the earthquakes which wrought such havoc in Central America just before the stupendous explosion of Coseguina, in Nicaragua, in 1835, and the earthquakes of gradually increasing violence which preceded the famous eruption of Vesuvius, in A.D. 70. It appears pretty certain that the determining cause of a volcanic eruption is the access of water to some mass of melted rock. The origin of the melted matter, whether locally developed or a portion of the still fluid interior mass of the earth, is immaterial to our present purpose. But, given this heated mass, the access of the water would produce violent explosions, which yet might not be enough to do more than shake the superincumbent strata. By shaking these, however, the cracks and channels by which the water sinks into the earth would be enlarged, and the explosive conversion into steam would go on till the force was sufficient to burst the crust at some point of weakness, and so result in the forcing up of the melted mass, either as so-called ashes or in a stream as lava. The fact that in so many cases the judicious examination of the movements produced by the shock, of the surface, and of movable objects on it, especially as observed by means of the instruments of precision now constructed for the purpose, indicates that the focus or centre of disturbance is situated at some depth below the surface, would seem to lend some support to this supposition. Thus Mallet determined the depth of the original shock of the earthquake in Calabria of 1857 as about 5 miles, and results varying in different cases from 4 to 14½ miles have been obtained in the case of some of the recent European shocks. One of the photographs referred to above showed the direction of the blow in a very remarkable manner, the corner of a building having been thrown off and hurled across a street, wrecking the opposite houses. In "Nature" for September 6th, 1883, p. 438, will be found a map of the island of Ischia, showing lines along which the effects were the same. The examination of these leads to the probability of a focus of disturbance not accurately at a point, but rather along a short line.

The exceedingly delicate instruments of various kinds which modern science makes use of have brought to light the fact that, even in what we are accustomed to think of as undisturbed countries, the earth's crust is in an almost constant state of tremor, and it is possible that some of these minor vibrations may be due to other than strictly volcanic causes,—such, for instance, as sudden fractures and slippings of rocks, or the collapse of subterranean cavities, such as are very likely to be produced by the secular cooling and contraction of the globe. It is a remarkable fact, but one that appears to be borne out by the examination of a large number of records of earthquakes, that these are more frequent in winter than in summer, and the local belief is that Stromboli is more active in stormy weather, when the barometer is low, than at other times. It would seem as if even such relatively small changes of pressure as those of the atmosphere on the earth's surface are responded to by the solid crust; how much more are such responses likely where great masses of material are being piled along the margin of an ocean area—the land area being at the same time relieved from the pressure.

The linear manner which volcanic phenomena so much affect was strikingly shown in the other great phenomenon of the year, the terrific explosion of Krakatoa, in the Straits of Sunda. Java has always been noted for the altogether exceptional violence of its volcanic eruptions. It needs but to recall those of Papandayang, Sumbawa, and Tomboro, to find parallels to that which so much aroused our interest in September last. The manner of them all is very similar. A mountain known to be a volcano is suddenly either completely blown away or enormously truncated. Little or no lava flows, but immense tracts of country are buried in ashes. Torrents of rain cause floods, which sweep away the terrified survivors of the explosion, and complete the ruin by enabling the ashes to set hard like cement. In addition to all this, mighty waves are raised in the sea which, invading the land, sweep all before them, and these, in the recent case, were the most destructive of all.

We have here obviously very different conditions and relations from those which bring about the tolerably regular and gentle puffings of Stromboli, the almost constant, quiet outpouring of lava from the great mountains of the Sandwich Islands, or even the usual paroxysms of Etna and Vesuvius. The lava in the interior of the earth must be at a high temperature, and such large quantities of water must find their way at intervals to it, that no gradual relief of pressure by the escape of fluid lava is sufficient, but the whole superincumbent mass, at any rate in the weak place—the volcano—is blown away at once. It should be noted that the rapid access of water would be facilitated by the melted matter coming nearer to the surface than is usually the case, and this would also give less power of resisting the sudden pressure of steam. In a paper on the ashes from Krakatoa, the Abbé Rénard draws attention to the fact that the numerous cavities of the glass and minerals of which it is made up contain no water, but only gas or air;* and this, notwithstanding the essential part that steam evidently plays in their eruption. He also points out that the fragments of the dust are by no means such as would result from trituration of a mass already solid to any great extent, but rather has the appearance of being produced by the sudden relief of pressure from a mass of molten rock containing, intimately mixed with it, highly compressed gases. To use a homely illustration,—such a mass as is produced in the manufacture of the so-called aërated bread, where the dough has been made with water, highly charged with carbonic acid. On running this out of the cylinder in which it has been prepared, the escape of the gas gives the bread its spongy texture. Carried a step further, it is easy to conceive it as actually bursting the mass into fragments.

Among the lavas which have been found in Sumatra, Java, and the various volcanic islands of those seas, the group called

* But the glass of which the ashes are mainly composed seems to contain water. (*See next note.*)

the Andesites is very common. They contain a Plagioclase Felspar, Hornblende, Augite, and frequently a rhombic Pyroxene, which from its dichroism is probably Hypersthene, although it shows none of the lamellar and acicular inclosures which are so characteristic of this mineral as found in larger masses and which produce the peculiar metallic glance observable in it. The dust ejected last August is exactly such as would result from the, so to speak, internal explosion of a fluid mass containing a few crystals of Felspar and of Pyroxenes, but the sudden cooling of which has prevented general crystallization. The quantity thus thrown out was prodigious and the depth to which the country for many miles around was covered was very great. At a distance of thirty miles it was constant employment for one man to keep the glass window of the compass-box of a ship washed, so that the steersman might be able to keep the course, and a specimen which I received through Mr. W. B. Cooley, of Wolverhampton, is described as having been swept up from the deck of a ship "500 miles out at sea from Sumatra," and it is added that "the air was darkened and the sea covered with floating pumice stone."*

* Since this was in print I have had the opportunity of examining and analysing another specimen of the ashes and one of the floating pumice collected on the ship "Berbice," which was within forty miles of Krakatoa at the time of the eruption, kindly sent to the Society by Captain Ross, whose steam yacht carried the dredging parties at Oban last year. The slight difference in composition between the ashes and the pumice is noticeable. Both samples were dried at about steam heat, but the pumice had previously been washed, as the salt contained in it made it somewhat sticky.

	ASHES.	PUMICE.
Silica	66·3	69·4
Alumina	14·8	15·9
Peroxide of Iron	1·6	1·2
Protoxide of Iron..	2·4	2·2
Lime	3·3	3·4
Magnesia	1·1	1·1
Oxide of Manganese	Traces	Trace
Soda..	5·2	4·2
Potash	2·2	2·3
Loss on Ignition	3·0	1·0
	99·9	100·7

Whether some of the finer parts of the ejected dust were carried up so far through the air as to produce the wonderful effects of aerial glow which, during some months, made the mornings and evenings all over the globe so marvellously beautiful, and which are said to have seriously affected the quantity of gas consumed in this country, may perhaps still be held to be not proved. Many considerations go to show the possibility, indeed almost the probability, of such a belief, and an objection which appears on the face of it to be almost insuperable, viz., the difficulty of imagining the possibility of fine dust being driven for such a distance through the densest part of the atmosphere, has been proved by some previous cases to have less force than we might be disposed to allow to it. For instances are recorded in which the fine ashes from a volcano have been carried more than one thousand miles in the direction *from* which the trade winds were blowing, showing that they had been forced through the lower stratum of air into that of the upper currents, the *return Trades*.

The recently reported volcanic phenomena in Alaska make it probable that if the particles producing the aerial glow were really due to terrestrial sources we may owe a portion at any rate of the atmospheric dust to the eruptions observed there.

Another effect of this great explosion was the enormous sea-wave which it raised. This was reckoned at nearly 100 ft. high, and affected the tide gauges at Panama, having traversed nearly half the circumference of the earth by a somewhat circuitous route. Unfortunately details appear deficient, or there might have been some valuable hints gleaned as to the average depth of the sea in various directions, similar to those deduced for the Pacific Ocean from observations of the rate of passage of the great wave raised by the Peruvian earthquake of August 13th, 1868, which traversed the space from Arica to the Sandwich Islands at the rate of 417 miles per hour, from which the average depth along that line was calculated to be 2,500 fathoms. The effect on the atmosphere, also, of the disturbance is said to have been observed at very distant stations, but not many details have as yet been published. The geographical effects were, as might be expected, very marked. The whole charting of the Straits of Sunda, a very much frequented highway for shipping, has been rendered useless, islands have been thrown up, and others are partially removed, shoals have formed, and others have disappeared.—(For a map of the Straits, see "Nature," January 17th, 1884, p. 269.)

Among the interesting and important matters which have been discussed among geologists, two, somewhat connected with each other, stand prominently out. As is well known, Sir R. I. Murchison recognized in the hornblendic gneiss of N. W. Sutherland and the Hebrides a possible equivalent of the great masses of gneiss to which American geologists have given the name of Laurentian. At any rate he found that these masses were separated from the strata above them by such discordance and unconformity that he ranked them as Pre-Cambrian. On the edges of the crumpled and highly inclined foliated gneisses he supposed that Cambrian strata, sandstones, and limestones were deposited. These are comparatively little altered, but are succeeded by another series of gneissic rocks, which, as they apparently overlie a certain limestone containing lower Silurian fossils, were mapped as Silurian, and were considered as a good case of the change by metamorphism of shales and grits into crystalline rocks.

For some time past geologists have been coming to the conclusion that the structure of the country is not so simple as this account would imply. Many workers have given their attention both to the relations of the rocks in the field and to their minute structure, and during the past year both our member, Prof. Lapworth, and our corresponding member, Dr. Callaway, of Wellington, who is already famous for his researches among these old rocks, have published their conclusions. The ill-health which we all regret so much has prevented the former from completing his papers in the "Geological Magazine" on "The Secret of the Highlands;" but those which have appeared, containing as they do the elementary general principles of earth foldings and movings, are very valuable to the student of the subject. He regards the Highland regions, excluding the granite district of the Grampians, as the worn-down stump of a great mountain mass, and points out that many, if not all, of the dispositions of strata which have been worked out by Heim for the chain of the Alps recur in the Highlands, only, as is but natural, in a state somewhat more difficult to recognize.

Dr. Callaway, taking the district of Assynt as his special example, concludes that what has been considered the Silurian gneiss is really an immensely older formation; that, in fact, it is Pre-Cambrian, though newer than the Hebridean gneiss. The sedimentary rocks deposited on the upturned faulted and denuded edges of these ancient gneisses are Sandstone, Quartzite, and Dolomite, but there is no evidence as yet as to their age. The whole mass of rocks was then by great and widespread earth movements folded back on itself, crumpled, faulted, and denuded. The crumpling and faulting extends in some places even to microscopic dimensions, and some slides which I have prepared from specimens collected by Prof. Lapworth in the neighbourhood of Loch Erribol show the effects of the pressure to which they have been subjected in another most interesting manner. A few felspar crystals are still recognisable, and in some cases the twin lamellæ are not straight and tolerably parallel as in the undisturbed state, but are contorted and twisted out of place. It is, perhaps, the most interesting point in the purely petrological consideration of the subject, that the evidences of the enormous pressure to which the rocks have been subjected, and under which they have apparently flowed like some viscous substance, are so marked. The finer constituents are in many instances arranged in lines round the larger quartz grains, in such a manner as to perfectly simulate the so-called fluxion structure observed in rocks which have flowed in a molten state. The enormous extent of some of the great overthrows of the Highlands must astonish us. Systems of strata have been thrown into folds a mile or more deep, and where these have, by the operation of greater pressure, been still further thrown over, the amount of dislocation may be imagined. As the mass which has undergone this process consisted of several series, the parts of which were unconformable to each other, the confusion introduced at the plane where with a little further movement a fault would be produced is somewhat prodigious. Here the rocks are, as it were, rolled out and laminated; all go alike—gneiss, granite, quartzite, limestone, and an examination, even cursory, of a few slides cut from such specimens impresses upon us the gigantic scale of earth forces more powerfully than, perhaps, even the field phenomena can. The great foldings are always accompanied by smaller folds, and these again by still smaller ones, till a mere waviness of the rock is the result. On the supposition that pressure is the cause of the metamorphism of rocks, we ought to find some trace of it here, but Prof. Bonney records that he has found no appearance of changes in that direction; that there is a certain deposition of quartz cementing the original grains, but these are always more or less easily determinable, and there is no structure approaching that of a true gneiss or crystalline schist. If Dr. Callaway's views turn out to be correct, and such a careful and learned observer may fairly be trusted till shown to be wrong, we have no hint in the Northern Highlands of the origin of the gneisses, as was the case when the upper series was supposed to be the metamorphosed equivalent of Silurian shales and grits. This problem still remains to exercise the observation and deductive genius of geologists, and we can only hope for a solution in the future. I venture to think that a hopeful path of enquiry and experiment is opened out by Daubrée and others, who have formed minerals by the action of certain substances, which finally leave little or no trace of their presence in the product, but the intermediary action of which has apparently enabled the silicate to crystallize at a comparatively low temperature. Many of the characteristic accessory constituents of the metamorphic rocks are among those which have been thus formed artificially, and we know that some of the compounds of chlorine were present, while the frequent presence of tourmaline and minerals containing fluorine in the contact zone round granite masses is also suggestive in this light.

While the conclusions of the Government Geological Survey have thus been impugned in Scotland, and, as above stated, observers have relegated what were considered to be metamorphosed Silurian to the Pre-Cambrian, or, as it is now usually called, the Archæan system, the present Director-General of the Survey, Dr. Archibald Geikie, has made a counter-attack in another district. Some years ago Dr. Hicks announced that he had made observations which went to show that the granitoid rock in the neighbourhood of St. David's, in Pembrokeshire, is really a highly metamorphosed sedimentary mass, still showing obscure bedding planes, and including in the coarse-grained gneissic rock bands of impure limestone, schists, and dolerites. Succeeding this is a great mass of volcanic rocks, felsites, breccias, and tuffs; and this again is followed by some comparatively unaltered slaty rocks. Over all these come the Cambrian strata, recognisable by the fossils, which Dr. Hicks himself has done so much to bring to light. The three great formations first mentioned are, therefore, Pre-Cambrian or Archæan. A similar succession has been observed in several other parts of our island; crystalline gneisses or granitoid rocks, schists, quartz-felsites, and volcanic tuffs, making up such regions as that constituting the Wrekin area, Malvern, parts of North Wales, and Anglesea. In fact, the St. David's district has seemed to give the key to the structure of most of the Archæan tracts of Britain. Although the exact correlation of the formations is still undecided, it may be mentioned that the researches of Prof. Lapworth and Mr. W. J. Harrison have brought to light in our immediate neighbourhood, at Nuneaton, quartz-felsites, and ash-beds, underlying, and apparently supplying, the material for the quartzite which, it seems probable, is, in its turn, succeeded by shales containing Cambrian fossils. In Leicestershire again there is a certainly very ancient, if not Archæan, series of rocks, principally composed of volcanic materials, and among them some doubtful felsites.

It will therefore be evident how great a disturbance of our ideas would be the result of the general acceptance of Dr. Geikie's contention, as developed in his paper read to the Geological Society last Spring, that the views held by the last Director-General, Sir Alexander Ramsay, are, after all, correct, and that there is no break of geological continuity such as would justify us in separating any of the older strata from the Cambrian system. Taking the St. David's district, Dr. Geikie considers that there is a continuous series of mixed volcanic and ordinary sediments with lava flows, from the earliest beds exposed to the upper members of the Cambrian system. Afterwards the whole conformable series was thrown up into an isoclinal fold with a general inclination to the north-west, during which process there has been considerable foliation developed. After this a great mass of granite rose through the south-east side, throwing out dykes and tongues of quartz-felsites. During this stage the various tuffs and shales have been changed in character, and have become in many parts finely crystalline in structure. Finally dykes of diabase have risen through the granite, but invade the other series of rocks.

It is evident that, between this account and the hypothesis of a Pre-Cambrian formation, there is no compromise possible. Dr. Geikie adduces an instance of contact metamorphism due to the Granite, which, on the other hand, Dr. Hicks denies, and points out especially the absence of such phenomena. To account for the rarity of such, it is asserted, in reply, that the amount of change in a rock, due to the contact of granite, varies very greatly according to its nature. A section which I have exhibited to the Society is a case in point: the granite has invaded a rather fine grit, and naturally there is but little scope for metamorphic action, and, in point of fact, very little has taken place. That the granite is intrusive here is nevertheless proved by the fact that at the junction line there is a decided arrangement of the quartz and felspar crystals, which are somewhat elongated and roughly perpendicular to the junction, forming a sort of fringe. On the other hand, a junction of schist and granite from Brazil Wood, near Leicester, shows a most curiously indeterminate zone, which, although there is a very marked change of colour and texture, seems difficult to assign definitely to either the altered or the altering mass.

The discussion has only begun, for we may be sure that the supporters of the hypothesis of an Archaean system will not be easily driven from their position, and will require much more definite and unmistakeable evidence of the intrusion of the granitoid rock than has yet been adduced. The microscopic evidence is not very certain. Unfortunately there seems no certain method at present known of discriminating between what we may perhaps be allowed to call true granites, and what are now called granitoidites. Prof. Bonney speaks of "a something hard to describe in words that differentiated this Crystalline rock of St. David's from all the undoubted granites with which he was acquainted;" but acknowledges that the decision is most difficult; and that it is so we may see from the fact that, on the one hand, such practised observers as Prof. Rénard, Prof. Zirkel, and Prof. Wichmann report "that the so-called Dimetian rock of St. David's is unquestionably a true granite," while, on the other, Mr. Davies did not admit that some of the rocks cited were granites at all, and said that, among five hundred specimens from about four hundred localities, he could find nothing resembling the St. David's rock, and added, that in the very heart of this supposed intrusive mass was found a breccia with fragments (some of them water-worn) of the stratified rock of the district. The last sentence of Mr. Davies' remarks introduces a further point in dispute. Dr. Hicks, and those who agree with him, tell us that a great part of the pebbles of the admittedly Cambrian conglomerate is derived from the older volcanic and metamorphic systems. On the other hand, the official geologists contend that they are almost all quartz or quartzite, and that there is no indication of the older rock of which they are fragments.

Both sides admit a very great amount of folding and crumpling, with subsequent denudation, but Dr. Geikie altogether denies the very extensive faulting which Dr. Hicks maps.

Passing now to another subject, I wish to mention the remarkable experiments undertaken by MM. Fouqué and Lévy, on the artificial formation of minerals and crystalline rocks, by means of purely igneous fusion. The book which describes their methods and the results obtained was published in 1882, but has not, I believe, been much known in England. I am the more disposed to speak of these experiments to-night because, in Birmingham, there are many who can command high temperatures, which are kept as nearly uniform as possible for considerable lengths of time, affording great facilities for the repetition of some, at any rate, of the experiments of the French savants.

Premising that their experiments were only performed on the basic rocks, on account of the much more infusible character of those belonging to the acidic series, a short recapitulation of the results they have obtained may help us in our attempts to follow the course of formation of natural rocks.

The source of heat employed was a blast gas furnace, the extreme temperature attainable being such that the platinum crucibles in which the fusions were performed were apt to be melted unless carefully watched. I imagine Fletcher's Injector furnace would answer the purpose admirably, as in his latest paper on heating by gas he speaks of the only limit to the heat obtainable being the resisting power of the fire-clay casings. The blast should be supplied by some means which does not require attention when once started; such, for instance, as an adaptation of those forms in which water rushing down a pipe draws air down with it, and compresses it in a cylinder at the bottom. The complete fusion of anorthite, leucite, and olivine requires the utmost heat which can be attained to. The authors state that the heat of a glass furnace is not sufficient for the fusion of these minerals, but is about enough for the annealing process for them mentioned later on.

The chief result of the experiments appears to me to be the discovery that a melted mass which, if cooled at once, furnishes a completely glassy mass, undergoes, when maintained for a certain length of time at a somewhat lower temperature, such a molecular re-arrangement that, on even rapid cooling, minerals separate out. This is the case with all the minerals usually met with in the basic rocks. When the mass has been kept in this way, at a temperature slightly above the point at which the glass softens, but below that at which the desired mineral fuses, there may be no appearance whatever of any differentiation of the parts; but such a rapid cooling as would, before this annealing process, have led simply to a glass, now gives rise to a development of crystals, with glass only in the interstices.

It is evident that this is parallel with the well-known method of producing Reaumur's porcelain from ordinary artificial glass, and with the experience of Messrs. Chance Bros., in the fusion of the Rowley Rag, for casting into ornamental facings for windows, doors, &c. There it was found that a prolonged annealing resulted in the conversion of the mass, which before was perfectly glassy, into one full of minute crystals, the first stage being the formation of beautifully perfect spherulites.

By this process MM. Fouqué and Lévy have been able to reproduce both the chief types of the basic rocks—both that in which the mass of the rock is made up of a great number of crystals of felspar and augite each independently crystallized, and that in which the felspar crystals form a sort of network, the interspaces of which are filled up wholly or partially with augite, the outlines of which have therefore no relation to the crystal planes of the mineral. The porphyritic character is also obtained where the consolidation has taken place in two stages, the first being that in which the large crystals of felspar, augite, and, where it is present, the olivine have separated out, a stage which has evidently been of considerable duration, and a second in which the mass, prepared by the maintenance in a viscous state, was ready to crystallize rapidly, though on a finer scale when erupted, and so cooled with comparative rapidity. It is quite possible that the differences observed in lavas as to the amount of crystallization to which they have attained may be connected with differences in the amount of this annealing process to which they have been subjected. If the mass is erupted in a condition of tolerably perfect fluidity it will more easily pass into the glassy state than if by slow cooling in the interior of the earth it has been elaborated and prepared to develop crystals on eruption and consequent cooling. Thus on the one hand we have the almost unique lavas of Mauna Loa, in the Sandwich Islands, which solidify almost constantly as glass, and on the other the lavas of Etna, which contain very little residual glass, except such as is shut into the larger crystals.

It is also probable that somewhat similar differences have determined, in the case of dykes, whether there shall be a boundary band in a glassy state, or whether the whole shall be crystallized. In the first case the injected mass must have been quite fluid, while in the second we may either suppose that it had already cooled to a viscous state, and had been maintained in that state for some length of time, or else that the whole mass of strata into which the eruption took place was at such a high temperature, or was of such bad conducting character, that the mere time necessary for the cooling allowed a sufficiently prolonged viscous stage for crystals to form from the beginning of the actual solidification.

The results which our authors have arrived at show that taking a fused mass, of composition similar to that of one of the basic rocks, we can, by making two stages of the cooling process, reproduce even the most minute details of the natural products. The examination of these show that the first stage of the consolidation has generally resulted in the formation of larger crystals than the second. Some minerals are found only as products of the first stage, such as olivine, which is never met with in actually microscopic grains. The leucite, again, has always separated before the felspar and augite, which often accompany it, though in this case the fact that augite is sometimes contained enclosed in the leucite is a difficulty, the explanation of which one experiment showed to be that the inclusions were shut in as liquid portions which, during the later cooling, had time to crystallize. In fact, the order of separation out of a mass in purely igneous fusion appears to be the natural one, viz., the inverse of the order of fusibility. Hence, when two felspars occur in a rock, the larger crystals are frequently of a different species from the crystals of the ground mass. If the former are anorthite, the latter are frequently labradorite or oligoclase, while the reverse order seems not to have been observed.

Scarcely less interesting are the failures. Neither quartz, mica, orthoclase, nor hornblende could be reproduced, and it would seem, therefore, that rocks containing these minerals were formed under other conditions than that of simple igneous fusion. A crystalline form of silica was indeed obtained, but it was not quartz, and had separated out from the mass before any other constituent, and at a temperature near that of melting platinum. Hornblende and oligoclase in about the proportions occurring in hornblende andesites formed an augite andesite.

Very important, too, are the results obtained in attempts to produce the various members of the felspar group intermediate between albite and anorthite. Their value lies in the fact that the true nature of these intermediate members is disputed. On the one side Tschermak considers that albite the pure soda felspar, and anorthite the pure lime felspar, are isomorphous, and that the other members are mixtures of these in varying proportions. The optical phenomena of a great number of specimens have been observed, and the composition determined on this supposition by Max Schuster. The other view is that oligoclase and labradorite are independent mineral species in exactly the same degree as the others, and this is the conclusion to which the experiments referred to would seem to point. Mixtures of albite and anorthite were taken in varying proportions, but the only resulting felspars were oligoclase and labradorite, with sharp distinctions in their optical characters, and no crystals showing intermediate characters, while again the passage to anorthite as the quantity of albite was diminished was also quite abrupt.

In addition to these imitations of the natural minerals, MM. Fouqué and Lévy produced the equivalents of oligoclase, labradorite, and anorthite, when strontia, baryta, and oxide of lead were substituted for lime. These present some very interesting peculiarities; some are apparently orthorhombic, while others are certainly triclinic, but do not present the usual twinning on the albite plan.

I fear, ladies and gentlemen, that you will think that what I have laid before you this evening bears perhaps too great marks of its essentially *clastic* origin, and I should have been glad to have been able to submit the materials to a more thorough metamorphism, but I trust you will not have found the subjects introduced to your notice quite devoid of interest, and I think they somewhat indicate the path along which geological inquiry is just now travelling towards a solution of some of the great chemical as well as stratigraphical problems which are propounded to us in the present condition of the earth's crust.

TWENTY-FIFTH ANNUAL REPORT

OF THE

BIRMINGHAM

NATURAL HISTORY AND MICROSCOPICAL SOCIETY,

READ AT THE

ANNUAL MEETING, HELD FEBRUARY 5TH, 1884.

The history of the Society during the past year has been one of unusual interest and importance in relation to its probable future prosperity.

The Committee have to report that the work of the Society has proceeded successfully in the usual way. During the last few months, however, a change of great magnitude has been made, necessitated by the circumstances in which the Committee found themselves, the result of which cannot be at once foreseen, but which the Committee hope and believe will tend to place the Society upon a firm and lasting foundation.

The Committee have for a long time felt the want of sufficient funds to carry on the work of the Society in the way which they considered to be best. To meet this difficulty, the voluntary Apparatus and Library Fund was created, but it was found that this, while barely sufficient, threw upon a comparatively small number of members the burden of providing advantages in which all shared. The authorities of the Mason College have also raised the rent payable by this Society, commencing with September last, from £16 to £50. Moreover, in order to secure the continuance of the *Midland Naturalist*, the loss of which the Committee believe would be a great blow to the progress of natural science in the Midlands, they have been obliged to guarantee a large number of subscribers to that magazine.

The Committee determined therefore to recommend to the members that the annual subscription be raised from Ten Shillings to One Guinea. They also proposed that a copy of the *Midland Naturalist* be sent monthly to each member, as well as two tickets for the Society's Soirée. By this means they hope to get money enough to carry on the work of the Society without appealing to a voluntary fund, and at the same time to secure to the members much greater advantages than they have hitherto enjoyed. The Committee have great pleasure in saying that these recommendations were carried at a Special General Meeting in January last.

By the exertions of Mr. W. R. Hughes and others, a new Section has been added to the Society, called the Sociological Section, for the study of Mr. Herbert Spencer's works. This Section holds its meetings on Thursdays, and has been very successful. Although it has struck out a path rather diverse from the previous work of the Society, yet its object cannot be considered an alien one, so long as the science of Anthropology is a branch of Natural History.

No large Conversazione was held last year. The Winter Session, however, was opened with a Soirée on a small scale, which was a great success, and was given, by permission of the authorities of the College, in the Examination Hall. The ordinary weekly meetings are now held in a new and convenient room on the first floor.

At the end of June, the Sixth Marine Excursion of the Society was made to Oban, and was much enjoyed by those who took part in it. The results of the dredging were satisfactory, and the new gear invented by Mr. W. P. Marshall worked admirably. A number of ladies took part in the excursion. Reports of the results will be hereafter presented, when the examination is completed.

One Day Excursion has been made to Oxford, which was unusually interesting, owing to the kindness displayed by Professor Westwood, Mr. G. C. Druce, and others, in conducting the party. There was also an Excursion to visit the Fisheries Exhibition, and Half-day Excursions to Earlswood, Nuneaton, and Barnt Green, and two others (under the auspices of the Sociological Section) to "George Eliot's Country" and "Shakspeare's Country" respectively.

The Meeting of the Midland Union of Natural History Societies for 1883 was held at Tamworth, under the presidency of Mr. Egbert de Hamel, at which the Darwin Gold Medal, awarded in 1882, was presented to Professor A. Milnes Marshall and Mr. W. P. Marshall for their paper on the Pennatulida.

At the end of 1882 the Society numbered 378 members, including four honorary vice-presidents, thirty-one corresponding members, five life members, and ten associates. Thirty-nine new members have been elected. Three associates have passed the age fixed as the limit of their privilege, and 114 have either died or resigned. The total number of members and associates is now 300, showing a net decrease of 78.

Among the losses which the Society has sustained, the Committee feel it their sad duty to draw especial attention to the death of two old and once active members, Dr. James Hinds, President in the year 1867, and Mr. William Willis, Vice-President in 1861, who made the beautiful drawings for Ralf's Desmidieæ. Both these gentlemen rendered important services to the Society in its early history, and helped to lay the foundation of its subsequent success.

There have been eighteen General Committee Meetings and nine Sub-committee Meetings held during the year, at which the attendance has been as follows:—

		Summoned.	Attended.
President	Mr. T. H. Waller	21	19
Vice-Presidents	Mr. W. G. Blatch	18	10
	Mr. R. W. Chase	20	16
Ex-Presidents	Mr. J. Levick	21	15
	Mr. W. R. Hughes	25	21
	Mr. W. Graham	25	14
	Mr. A. W. Wills	21	5
Treasurer	Mr. C. Pumphrey	22	12
Librarian	Mr. J. E. Bagnall	18	16
Curators	Mr. R. M. Lloyd	18	18
	Mr. H. Miller	18	5
B. Section Sec.	Mr. J. F. Goode	22	19
G. Section Sec.	Mr. A. H. Atkins	16	7
S. Section Sec.	Mr. A. Hayes	5	2
	Mr. W. Greathead	9	4
General Secretaries	Mr. J. Morley	27	27
	Mr. W. B. Grove	18	12

GENERAL COMMITTEE.

	Summoned.	Attended.
Mr. E. W. Badger	18	2
Mr. W. J. Harrison	13	2
Mr. W. P. Marshall	22	14
Mr. E. Tonks	23	10
Mr. S. Wilkins	8	4
Mr. W. H. Wilkinson	18	9

During the year there have been 25 General Meetings, with an average attendance of 24·5, at which the following thirteen papers have been read:—

On the Poisoning of some Actiniæ	W. R. Hughes, F.L.S.
The Geography and Botany of the Rea	Rev. H. Boyden, B.A.
The Classification of the Uredines (*communicated by Mr. J. E. Bagnall*)	C. B. Plowright, M.R.C.S.
An Evolutionist's Notes on Transmigration	W. Greatheed.
Notes on Plants from Hunstanton, Norfolk, collected by Mr. R. W. Chase	J. E. Bagnall.

The British Species of Pilobolidæ, with a Synopsis of the European Species..	W. B. Grove, B.A.
Vertebrate Egg-life	W. Greatheed.
Recent Discoveries in Fresh-water and Marine Life	T. Bolton, F.R.M.S.
Cremation	W. H. France.
New and Noteworthy Fungi, chiefly from the Neighbourhood of Birmingham..	W. B. Grove, B.A.
Our Marine Algæ, with Notes on the three Classes, Melanosperms, Rhodosperms and Chlorosperms	Rev. H. Boyden, B.A.
On the Continuity of Protoplasm (Part I)	Professor W. Hillhouse, B.A.
The Great Kimberley Diamond Mine ..	W. P. Marshall, M.I.C.E.

The following Papers have been read at the meetings of the Biological Section:—

On the Study of Ornithology.. ..	R. W. Chase.
Re-classification of the Conjugate Algæ	A. W. Wills.
Note on Œcidium berberidis (*communicated by Mr. J. E. Bagnall*) ..	M. C. Cooke, M.A.
Notes on some Plants collected in the Lake District, by Mr. W. R. Hughes, F.L.S	J. E. Bagnall.
The Recent Sunsets and Sunrises ..	W. P. Marshall, M.I.C.E.

The following Papers have been read at the meetings of the Geological Section:—

Note on some Glacial Markings in the Red Marls	A. H. Atkins, B.Sc.
Recent Investigations in the Glacial Geology of the Midlands	H. W. Crosskey, LL.D., F.G.S.
The Ancient Life History of the Earth (illustrated by lantern views)	W. J. Harrison, F.G.S.
The Felspars	T. H. Waller, B.A., B.Sc.
The Geology of Scotland, with especial reference to the neighbourhood of Oban	Professor C. Lapworth, F.G.S.
Fossil Spiders and Scorpions	Rev. P. B. Brodie, M.A., F.G.S.
Report on the Rocks and Minerals collected during the Marine Excursion to Oban	T. H. Waller, B.A., B.Sc.

The following Papers have been read at the Meetings of the Sociological Section:—

1883.		Meetings.	Subject.	Opener or Leader.
May	3 ...	I. Ordinary ...	Education Essay, ch. I.	Mr. Greatheed.
June	2 ...	Special ...	Excursion to George Eliot's Country	Mr. E. W. Badger.
,,	7 ...	II. Ordinary ...	Education Essay, ch II.... ...	Mr. Greatheed.
July	12 ...	III. ,, ...	,, ,, ch. III. ...	Mr. L. J. Major.
,,	19 ...	IV. ,, ...	,, ,, ch. IV. ...	Mr. L. J. Major.
Oct.	1 ...	V. ,, ...	Principles of Biology, ch. I. ...	Dr. Hill, F.I.C.
,,	6 ...	Special ..	Excursion to Shakespeare's Country	Mr. Rabone.
,,	25 ...	,, ...	Paper on George Eliot's Country	Mr. E. W. Badger.
Nov.	1 ...	VI. Ordinary ...	Principles of Biology, ch. II. ...	Dr. Hill, F.I.C.
,,	15 ...	Special ...	Paper.—"Some Jottings about Shakespeare and Stratford"	Mr. Rabone.
Dec.	6 ...	VII. Ordinary ...	Principles of Biology, ch. III. and IV.	Mr. F. J. Cullis.
	20 ...	VIII. ,, ...	,, ,, ch. V. and VI.	Mr. J. O. W. Barratt, B.Sc.

The following were the chief specimens exhibited at the General and Sectional Meetings throughout the year. Those marked with an asterisk (*) are new to the district:—

Mr. S. Allport, pseudomorphs of felspar-crystals.

Mr. J. E. Bagnall (Phanerogams):—*Viola hirta*, from Alveston Pastures, and var. *flore-albo* (rare), from Wootton Wawen; *Viola sylvatica* var. *Reichenbachiana*, from Preston Bagot; *Bromus racemosus*, *Galium tricorne*, from Binton and Bardon Hill; *Matricaria chamomilla*, from Middleton; *Prunus cerasus*, from Oakley; *Œnanthe fistulosa*, from Waring's Green; *Helosciadium inundatum*, from Little Ladbrook; **Rosa bibracteata* (rare), **Juncus obtusiflorus*, from Anstey; *Campanula latifolia* (rare), from Combe fields; *Geranium pratense*, from Brinklow; *Lycopsis vulgaris*, from Binley; *Campanula Trachelium*, *Agrostis nigra*, *Tilia parvifolia*, *Centaurea nigra* var. *radians*, *Juncus Gerardi*, *Arundo Epigejos*, from Ragley; *Hieracium maculatum*, from Hampton; *Lemna polyrrhiza*, *Anthemis arvensis* (rare), *Polygonum arenastrum*, *Silaus pratensis*, *Arctium minus*, from Escole's Green; *Paris quadrifolia* (in fruit), from Oldbury; *Drosera rotundifolia*, *Empetrum nigrum*, and other plants, from Milford; *Carex præcox*, *Mœnchia erecta*, from Yarningale Common; *Cratægus oxyacanthoides*, from Lapworth; *Salix Smithiana*, from Seas Wood; *Equisetum fluviatile*,* from Seas Pool; **Nitella flexilis*, **N. opaca*, *Chara fragilis*, *Bromus commutatus*, *Littorella lacustris*, *Equisetum sylvaticum*, *Genista tinctoria*, *Helosciadium inundatum*, *Scirpus acicularis*, **Carex elongata*, *Festuca tenuifolia* (all rare), and *Carex curta* (very rare in the county), from Earlswood; *Nardus stricta*, from Baxterly Common and Forshaw Heath; *Equisetum maximum*, from Bentley Park; *Ceratophyllum submersum*, *Acorus Calamus*, *Carex pseudo-cyperus*, *Salix alba* var. *cærulea*, *S. pentandra*, from near Henfield and Temple Balsall; *Scirpus Tabernæmontani*, *Carex distans*, from Itchington; *Rosa gallicoides*, *Bromus erectus* var. *villosus*, from Chesterton; *Pimpinella magna*, *Comarum palustre*, *Malachium aquaticum*, *Menyanthes trifoliata*, *Potamogeton rufescens*, *P. polygonifolius*, from Tile Hill; *Epilobium tetragonum*, *Chara vulgaris* var. *longibracteata*, *Lotus tenuis*, *Carduus eriophorus*, *Linaria Elatine*, *L. spuria*, *Urtica urens*, *Chenopodium polyspermum*, *Galeopsis Ladanum*, **Rosa stylosa*, etc., from Drayton; *Iris fœtidissima*, from Wilmcote; **Scirpus maritimus*, from Flecknoe: *Orchis pyramidalis*, from Stratford; *Scabiosa columbaria*, from Bardon Hill; *Epipactis latifolia*, from Stoneleigh; *Arundo calamagrostis* (very rare), from near Solihull; *Narthecium ossifragum* (very rare), from a new locality, near Marston Green; *Plantago arenaria*, from near Warwick; and many rare plants for Messrs. W. R. Hughes, C. Bailey, F. Enock, S. Wilkins, and J. B. Stone. (Cryptogams, Mosses)—*Ulota intermedia*, *Funaria fascicularis*, *Mnium rostratum* (all rare), *Pleuridium nitidum*, and *Campylopus fragilis* (in fruit, rare), from Hampton-in-Arden; *Tortula muralis* var. *rupestris* (rare), *T. convoluta*, *T. revoluta*, *T. aloides*, *T. unguiculata* *var. *apiculata*, from Fillongley; *Encalypta streptocarpa* (rare), from Arley; *Fontinalis antipyretica*, from Waring's Green; **Gymnostomum squarrosum*, from Kingsbury; *Hypnum pratense* (rare), from Earlswood; *Orthotrichum rivulare*, *Tortula mucronata* (in fruit), and *Hypnum chrysophyllum*, from Wootton Wawen; *Tortula latifolia* (in fruit), and *T. marginata*, from near Sherbourne; *Sphagnum papillosum*, *S. rubellum*, *S. auriculatum* (all rare), from Marston Green; *S. fimbriatum* (in fruit), from Bentley Park; *Gymnostomum tenue* (very rare), from Shrewley Common: *Dicranum montanum* (new to Worcestershire), from Shrawley Wood; and **Orthotrichum saxatile* (found by Mr. R. Rogers, and new to North Warwickshire), from Hampton-in-Arden. (Hepaticæ):—*Lunularia vulgaris*, from Hampton; *Targionia hypophylla*, *Kantia arguta*, from Habberley Valley; *Diplophyllum albicans* (in fruit), from Chalcot; **Scapania irrigua*, from Earlswood; *Anthoceros punctatus* (rare), from Maxtoke; *Pellia epiphylla*, *Conocephalus conicus* (in fruit), from Arley; **Jungermannia inflata* (rare), from Baxterley; and many species of Mosses, etc., for Mr. J. B. Stone. (Fungi):—**Agaricus vernus*, *Ag. leptocephalus*, *Ag. tenuis*, *Ag. galopus*, *Lactarius deliciosus*, *L. glyciosmus*, *Cortinarius elatior*, *Boletus elegans*, from Coleshill Heath; *Ag. squamosus*, **Ag. tuberosus*, **Russula lutea*, and **Scleroderma Geaster*, from Middleton; *Ag. inopus*, *Ag. sublateritius* *var. β, from Packington; *Ag. spermaticus*, **A. clavipes*, **Boletus bovinus*, *B. scaber*, *B. piperatus*, *Cortinarius subferrugineus*, from Coleshill and Middleton; *Boletus edulis*, **Lactarius pyrogalus*, **L. camphoratus*, *Russula integra*, from Baddesley Clinton; *A. sphagnorum*, from Hampton; *Auricularia mesenterica*, from Upper Eatington; *Cortinarius cinnamomeus*, from Itchington; *Ag. chrysophaeus*, from Ragley Park; *Russula fœtens*, **Lactarius pergamenus*, **L. cilicioides*, *L. camphoratus*, *Cantharellus cibarius*, from Hurley; *Ag. asterosporus*, *Ag. pascuus*, *Ag. cerrinus*, *Ag. fusipes*, *Ag. conopileus*, *Cortinarius ochroleucus*, **C. decumbens*, *C. sanguineus*, *Russula fellea*, *R. rubra* (rare), **Lactarius pallidus*, *Boletus striæpes*, and other Fungi, from Middleton; collected during a visit of Dr. Cooke; *Ag. odorus*, **Ag. prunulus*, *Ag. hydrophilus*, **Cortinarius torvus*, from Fillongley; **Russula drimeia*, from Packington; **Hydnum auriscalpium*, from Hampton; **Ascobolus denudatus*, from Handsworth; *Gomphidius glutinosus*, from Marston Green; *Ag. flavidus*, from Ragley Woods; **Phyllosticta violæ*, from Drayton. (Lichens):—*Ramalina farinacea*, *R. fraxinea*, and **Peltigera spuria* (rare), from Hampton; *Usnea barbata* var. **hirta*, from Arley; **Parmelia olivacea*, from Coleshill; *P. saxatilis*, from

Oakley Wood; *Usnea hirta*, *Bæomyces rufus*, from Shrawley and Stourport; *Lecanora atra*, *L. ulmicola*, *L. varia*, and *Pertusaria communis*, from Sherbourne; also for Dr. M. C. Cooke, *Cyathus striatus*, *C. vernicosus*, from Norfolk, and many other Fungi; and for Mr. C. B. Plowright, *Geoglossum olivaceum*, *Ag. ambustus*, and other Fungi from Hereford; *Ag. humilis*, *Hygrophorus lætus* *Cortinarius rigens*, *C. pholideus*, and other Fungi from Sandringham; *Panus torulosus*, *Ag. carcharias*, *Ag. flavo-brunneus*, *Lactarius exsulsus*, *Russula drimeia*, *R. ochroleuca*, *Boletus bovinus*, *Polyporus spumeus*, *Hydnum auriscalpium*, *Cortinarius scandens*, *Peziza rutilans*, *P. cochleata*, and other rare Fungi from near King's Lynn.

Mr. Bernard Baker, a Tarantula spider and nest.

Mr. W. G. Blatch, **Cryptarcha strigata*, and **C. imperialis*, two beetles from Knowle.

Mr. W. G. Blatch, jun., two linnet's eggs from the same nest, one of the normal colour, the other paler and unmarked.

Mr. Thomas Bolton, *Chilomonas spiralis*, a new Infusorian, discovered and named by himself; **Hemidinium nasutum*, from Sutton Park (new to England); **Podophrya limbata*, from a fresh-water habitat near Birmingham, only marine habitats having been previously recorded; *Caligus Stromii*, a parasite on salmon, from Christchurch, Hants; a new capito-branchiate marine annelid, *Haplobranchus æstuarinus*, from the estuary of the Thames; *Foliaceus Coregoni*, ♀ and ♂, a fish parasite, from the Royal Aquarium, Westminster; *Clathrulina elegans* (rare) and *Limnias annulatus*, from the United States of North America.

Rev. H. Boyden, a small collection of plants from the South of France and South of Portugal, made by Rev. F. H. Thompson; also a collection of sea-weeds.

Mr. R. W. Chase, *Charadrius morinellus*, from near Bristol; *Calcarius lapponicus*, ♀ and ♂, in adult summer plumage, *Turdus pilaris* (young), and *T. iliacus* (young), all from Norway; *Tringa subarquata*, in summer plumage, from Breydon, Norfolk; *Phalaropus hyperboreus*, in winter plumage, from near Boston, and in the down from Unst, Shetland; *Somateria mollissima*, and *Fratercula arctica*, in the down, from the Farne Islands; *Stercorarius crepidatus*, in the down, from Shetland; *Archibuteo lagopus*, the Rough-legged Buzzard, from St. Olive's; a nest and eggs of *Rallus aquaticus*, the Water-rail, from Horsey, Norfolk; fragments of gold-bearing quartz, from a mine near Dolgelly; and a specimen of basalt from the Farne Islands.

Mr. Thomas Clarke, two microscopic slides of objects mounted in spirits of wine, 64 over proof, in 1881, which did not yet show any signs of leaking; *Leptodora hyalina*, and other Entomostraca, mounted by this process, with the use of a peculiar cement; and glass-slides with an etched ring (produced by hydrofluoric acid) on the surface, for the purpose of obtaining greater security for the adhesion of the cement.

Mr. F. J. Cullis, *Linnæa borealis* and *Rubus arcticus*, sent by Miss Mickwitz, from Helsingfors, Finland.

Mr. R. W. Felton, Franklin Quail from Suffolk, and a young Hobby from Herefordshire.

Mr. W. H. France, a quantity of *Merulius lacrymans*, the dry-rot fungus, which had sapped and destroyed the greater part of his dining-room floor, causing it to fall in.

Mr. J. F. Goode, ova of Cleanser Swimming Crab, *Portunus depurator*, and of Masked Crab, *Corystes cassivelaunus*: a slide of Marine Entomostraca, taken in the tow-net, near Oban; *Colletonema neglectum* and *Vaucheria geminata*, from Handsworth; and *Coccochloris Brébissonii*, a minute species of Algæ.

Mr. W. Greatheed, a specimen of *Tænia Solium*, twenty feet long.

Mr. W. B. Grove, the following Fungi from this neighbourhood (Hymenomycetes):—*Amanita vaginata*, from Coleshill Pool and Four Oaks Park; *A. mappa*, from Sutton Park, Coleshill Pool, and Trickley Coppice; *A. muscaria*, from Sutton Park; *A. aspera*, from Coleshill Pool; *Lepiota procera*, from Edgbaston Park; **Tricholoma stans*, from Edgbaston Park; **T. virgatum*, Coleshill Pool and Edgbaston Park; *T. brevipes*, from Sutton; *Clitocybe metachroa*, from Trickley Coppice; **C. ditopus*, from Edgbaston Park; *C. fragrans*, from Hints Wood; *Collybia platyphylla*, from Sutton Park; *C. maculata*, from Sutton Park and Coleshill Pool; *C. dryophila*, from Coleshill Pool and Four Oaks Park; **Mycena pseudo-pura*, from New Park, Middleton; *M. sanguinolenta*, *M. galopus* *var. *candida*, and *M. tenerrima*, from Four Oaks Wood; *Omphalia pyxidata*, from Harborne; **O. fibula*, from Warley Woods; **Pleurotus fimbriatus*, from Handsworth; **P. applicatus*, from Four Oaks Park; *Pluteus nanus*, from Sutton and Four Oaks Park; **Entoloma sericeum*, from Rubery Hill; *Nolanea pascua*, from Four Oaks and Sutton Park; **Claudopus variabilis*, from Sutton Park; *Pholiota squarrosa*, from Sutton Park and Hints Wood; *P. spectabilis*, from Coleshill Pool; *Inocybe rimosa*, from Sutton Park and Cleeve Priors; *I. asterospora*, from Four Oaks Park; *I. geophylla*, from Coleshill Pool; **Hebeloma versipelle*, from Sutton; **Naucoria cucumis*, from Sutton; **Stropharia melasperma*, from Four Oaks Park; *S. squamosa* and *Hypholoma epixanthum*, from Sutton; **H. pyrotrichum*, from Langley; *H. Candolleanum*, from Hints Wood; *Psilocybe uda* and *var. *polytrichi*, from the Lickey Hills; *Panæolus campanulatus*, *Coprinus niveus*, and *Bolbitius titubans*, from Four Oaks Park; *Cortinarius elatior*, from Hints Wood;

C. sanguineus*, from Sutton Park; *C. cinnamomeus*, *C. castaneus*, and **C. armillatus*, from Coleshill Pool; **C. hemitrichus*, from Sutton Park; *Hygrophorus pratensis*, from Coleshill Pool; *H. virgineus*, from Four Oaks Park; *L. cilicioides*, from Langley; *L. turpis*, from Sutton Park, Edgbaston Park, Four Oaks Park, and Coleshill Pool; *L. hysginus* (rare), from Edgbaston Park; *L. uvidus*, from Four Oaks Park and Coleshill Pool; *L. pyrogalus*, from New Park, Middleton; *L. vellereus*, from New Park and Edgbaston Park; *L. deliciosus*, from Sutton Park; *L. pallidus*, from Four Oaks Park; *L. glyciosmus*, from Coleshill Pool; *L. mitissimus*, from Four Oaks Park; *Russula nigricans*, from Sutton Park and Solihull; **R. depallens* and **R. fellea*, from Edgbaston Park; *R. cyanoxantha*, from Coleshill Pool; *R. emetica* and *R. ochroleuca*, from Four Oaks Park; *R. fragilis*, from Coleshill Pool and Solihull; *R. integra*, from Coleshill Pool and Four Oaks Park; *R. depallens*, from Edgbaston Park, *R. alutacea*, from Sutton and Four Oaks Parks; *R. drimeia*, from Sutton Park (very rare); *Nyctalis parasitica*, on *Russula adusta*, from Solihull; **Marasmius ramealis*, from near Coleshill Pool; *Lentinus cochleatus*, from New Park, Middleton; *Lenzites betulina*, from Marston Green; **L. sepiaria*, from Sutton; *Boletus flavus*, from Earlswood, Sutton Park, and Coleshill Pool; *B. badius*, from Edgbaston Park; *B. chrysenteron*, from Four Oaks Park; *B. subtomentosus*, from Coleshill Pool; *B. edulis*, from Sutton Park; *B. luridus*, from Langley; *B. scaber*, from Sutton Park; **Polyporus rufescens*, from Solihull Park (collected by Mr. W. H. Wilkinson); **P. giganteus*, from Edgbaston Park; *P. hispidus*, from Sutton Park and Hints Wood; *P. spumeus*, from Sutton; *P. dryadeus*, from Stonebridge and Barton Green; *P. betulinus*, from Coleshill Pool; *P. fomentarius*, from Salford Priors; *P. annosus*, from Sutton Park and Coleshill Pool; *P. abietinus*, from Hints Wood; *P. obducens*, from Harborne; *P. molluscus*, from Coleshill Pool; *P. sanguinolentus*, from Sutton; **Ptychogaster albus*, the conidial stage of *Polyporus Ptychogaster*, from Sutton Park; *Trametes gibbosa*, from Sutton and Sutton Park; **T. serpens*, from Sutton; *Hydnum ferruginosum*, from Sutton; *Phlebia merismoides*, and *var. *albo-marginata*, Phillips, both from Sutton; *Thelephora laciniata*, from Warley Woods; *T. puteana*, from Edgbaston (collected by Mr. C. B. Caswell; *Hymenochæte rubiginosa*, from Sutton; *Auricularia mesenterica*, from Sutton; **Corticium evolvens*, from Warley Woods; **C. giganteum*, from Sutton Park; *C. quercinum* (on beech) and *C. cinereum*, from Warley Woods; *C. incarnatum* and *C. sambuci*, from Sutton; *Cyphella villosa*, from Warley Woods; **C. Curreyi*, from Erdington; **Clavaria coralloides* and *C. cinerea*, from New Park, Middleton; *C. cristata*, from Coleshill Pool; *C. rugosa*, from Trickley Coppice; **C. stricta*, from Handsworth; *C. inæqualis*, from Sutton; **C. pistillaris*, from New Park, Middleton; **Calocera viscosa*, from Coleshill Pool; *Typhula Grevillei*, from Harborne; **Pistillaria micans*, from Solihull; *P. quisquiliaris*, from Trickley Coppice; *Tremella foliacea* and *T. indecorata*, from Sutton; *Exidia glandulosa*, from New Park, Middleton; *Dacryomyces deliquescens* and **Ditiola radicata*, from Sutton. (Gastromycetes):—*Lycoperdon giganteum*, from Wixford. (Hypodermeæ):—Xenodochus carbonarius* (rare), from Water Orton; *Phragmidium mucronatum*, from Stonebridge; *P. violaceum*, from Solihull and Barton Green; *P. obtusum*, from Hampton-in-Arden; *Triphragmium ulmariæ*, from Hampton and Solihull; **Puccinia Baryi* (very rare), from Harborne; *P. luzulæ* (rare), from Edgbaston; *P. violarum*, from Hampton; *P. pulverulenta*, from Hampton and Solihull; *P. galiorum*, from Hampton, Solihull, and Barton Green; *P. suaveolens*, from Water Orton; **P. coronata*, from Berkswell; *P. striola*, from Barton Green; **P. straminis*, from Solihull; *Uromyces ficariæ*, from Marston Green; **U. poæ*, from Harborne; *Uredo bifrons*, from Marston Green; *Melampsora betulina*, from Stonebridge; *M. salicina*, from Coleshill; *M. tremulæ*, from Coleshill Pool; *Ræstelia lacerata*, from Water Orton; *Œcidium depauperans*, from Perry Barr; *Urocystis pompholygodes*, from Solihull. (Hyphomycetes):—**Fusidium cylindricum*, Corda, from Edgbaston Park; *Helicomyces roseus* and *Oidium chartarum*, from Sutton; *Penicillium candidum*, from Edgbaston; **Botrytis coccotricha* (new to Britain), from Kenilworth; **Dactylium oboratum*, from Sutton, showing a very probable transition to *D. roseum*; **Torula pulveracea*, from Marston Green; **T. ovalispora*, *T. sporendonema*, *Bispora monilioides*, *Sporodesmium Lepraria*, **Speira toruloides*, *Coniothecium glomeratum*, from Sutton; **Monotospora megalospora*, from Coleshill Pool; *Polythrincium trifolii*, from Earlswood and Salford Priors; **Helminthosporium stemphylioides* (very rare), **H. obclavatum* (new to Britain), and **H. folliculatum* var. *brevipilum*, from Sutton; *Acrothecium simplex*, from Harborne; **Dendryphium comosum*, from Water Orton; **Helicosporium viride*, and **Triposporium elegans*, from Sutton; *Macrosporium cheiranthi*, from Harborne; *Isaria umbrina*, from Sutton Park; **Bactridium helvellæ*, from Sutton; **Epicoccum purpurascens* (new to Britain), from Edgbaston Park; *Menispora ciliata*, from Sutton. (Melanconieæ):—**Steganosporium cellulosum*, from Sparkhill. (Sphæropsideæ):—*Phyllosticta vulgaris* var. *loniceræ*, from Water Orton; **Darluca filum*, from Harborne; **Dinemasporium hispidulum* from Sutton; **D. graminum*, from Edgbaston. (Ascomycetes):—*Sphærotheca Castagnei*, *Uncinula bicornis*, **Erysiphe tortilis*, and *E. Martii*, from Barton Green; *Erysiphe communis*, on Trifolium, from Solihull; **Helvella crispa*, from New Park, Middleton; *Rhizina* *undulata*, from Sutton Park and Coleshill Pool; *Peziza cochleata*, **P. omphalodes*, **P. umbrata*, Fries, *not* Cooke, from Sutton; *P. stercorea*, from Quinton; *P. nivea*, from Berkswell and Sutton; **P. hyalina*, **P. Chavetiæ*, **P. fusca*, **P. cyathoidea*, **P. coronata*, from Sutton; *P. cinerea* and **P. palearum*, from Edgbaston; *Helotium aciculare*, from Four Oaks Park; *H. æruginosum* (mycelium only), from Crackley Wood, Kenilworth; **H. lutescens*, *H. pallescens*, *H. claroflavum*, **H. pruinosum*, from Sutton; *Ascobolus furfuraceus*, from Edgbaston and Sutton; **A. glaber*, from Sutton; *Hysterium curvatum*, from Berkswell; *Hypomyces aurantius*, *Nectria sanguinea*, **N. flavida*, *N. aquifolia*, **N. mammoidea*, from Sutton; *N. Peziza*, from Barton Green; *H. coccineum*, from Sutton Park; *H. fuscum*, from Solihull; *H. rubiginosum* and *H. multiforme*, from Sutton; **Eutypa velutina*, **E. scabrosa* and *E. lata*, from Marston Green; *Dothidea graminis*, from Berkswell; *Diatrype verrucæformis* and *D. ferruginea*, from Marston Green; *D. stigma*, with its customary parasites *Nectria episphæria* and *Helotium pruinosum*, from Earlswood; **Melanconis aceris*, Plowright, and *Cucurbitaria cupularis*, from Marston Green; **Rosellinia ligniaria*, from Sutton; *Sphæria aquila*, from Sutton and Water Orton; *S. acuminata* and *S. doliolum*, from Solihull; *S. pulvis-pyrius*, from Halesowen; *S. acuta* and *S. rubella*, from Sutton; **Sordaria breviseta*, from Water Orton; **S. fimeti*, from Quinton; *Stigmatea Robertiani*, from Hampton-in-Arden and Barton Green. (Phycomycetes):—*Peronospora grisea*, from Bidford, Marston Green, and Solihull; **P. arborescens*, from Wixford; *P. effusa*, from Solihull; *P. nivea* and **P. ficariæ*, from Sutton; *Cystopus candidus*, from Earlswood; *Pilobolus Kleinii* and **P. œdipus* (new to Britain), from Sutton; **Mucor macrocarpus* (new to Britain), from Sutton and Four Oaks Parks; **M. fusiger*, from Edgbaston Park; the zygospores of *M. mucedo*, from Edgbaston; **Sporodinia grandis*, from Coleshill Pool, on Cortinarius; **Piptocephalis Freseniana* (new to Britain), from Edgbaston. (Myxomycetes):—*Ethalium septicum*, from Coleshill Pool; **Badhamia hyalina*, from Edgbaston Park; **Chondrioderma physarioides*, from Sutton; *Stemonitis fusca*, from Barton Green; **Tubulina cylindrica* (for Mr. R. M. Lloyd), from Birmingham; **Cribraria aurantiaca*, **Trichia chrysosperma*, *T. pyriformis*, *Hemiarcyria rubiformis*, **H. clavata*, *Reticularia umbrina*, *Lycogala epidendron*, and **Perichæna depressa*, from Sutton. Also *Ag. atroalbus*, *Ag. asterosporus*, *Russula fellea*, *Cantharellus aurantiacus*, *Diatrype disciformis*, from the Wrekin; also (for Mr. T. Bolton) *Puccinia betonicæ*, from Yorkshire; (for Mr. H. T. Soppitt) *P. chondrillæ*, *P. chysosplenii*, *Æcidium prenanthis*, *Ustilago Kühniana*, *U. bromivora*, *Bactrodesmium abruptum*, and other Fungi, from Yorkshire; (for Mr. T. Birks) *Æcidium* *thalictri* and *Puccinia Magnusiana*, from Goole; (for Mr. Bodger) *Clavaria fragilis*, from Peterborough; (for Mr. J. A. Wheldon) *Peziza atrata*, from Cambridge, and *Sphæria lirella*, from Scarborough; (for Mr. W. H. Wilkinson) *Coleosporium petasitis*, from Arley; and (for Mrs. Dalton, of Peterborough) a large number of exquisite water-colour drawings of Fungi, especially of the Hymenomycetes.

Mr. W. J. Harrison, belemnites from the Upper Lias of East Leicestershire; fossil wood from Sheppey; Coal Measure shale, glacially striated, from Acocks Green; a tooth of Carcharodon, from Malta; the quartz crystals known as "Isle of Wight diamonds"; agate nodules from North Wales; and a series of rock specimens from Sweden, China, and Charnwood Forest.

Mr. W. J. Harrison, jun., rocks from Criccieth, and quartz crystals from Beddgelert, North Wales; *Ammonites cordatus* from the Oolite of Desborough; and spines of Echinodermata, in chalk, from Grays, Essex.

Mr. David Hooper, *Arbutus Uredo*, *Myrica Gale*, *Narthecium ossifragum*, and other plants from Killarney; *Crithmum maritimum*, from County Cork.

Mr. W. R. Hughes, *Zoanthus Couchii* var. *liber*, *Sagartia viduata*, *Pennatula phosphorea*, and *Antedon rosaceus* from Oban; a series of slides, prepared by Mr. F. W. Sharpus, illustrating the development and structure of the Cephalopoda.

Mr. J. Levick, *Mimulus luteus*, wild, from the banks of the Rother, near Midhurst, Sussex.

Mr. W. P. Marshall, *Acæna microphylla*, a small and curious rock plant; the apparatus prepared for the Oban Excursion, 1883, especially that invented with a view to obtain perfect specimens of Funiculina.

Mr. C. H. Matley, fossiliferous quartzite pebbles, from Castle Bromwich, containing species of Phacops, Orthis, Lingula, and Riberia.

Mr. J. Morley, a section of *Hippuris vulgaris*: *Ceramium echinatum*: the rare white variety of *Lamium purpureum*, from a garden; *Helleborus fœtidus*, *H. viridis*, and *Daphne Laureola*, for Mr. T. Clarke, from Tanfield, Yorkshire.

Mr. C. Pumphrey, a number of Swiss, Italian, and Channel Island plants, in flower, from his garden; spiral fibres of root of lily; the seeds of *Parnassia vulgaris*: and *Pyrola rotundifolia*, from Southport.

Mr. W. Southall, *Gentiana Pneumonanthe*.

Mr. E. H. Wagstaff, *Triarthra longiseta*, from near Quinton; *Argulus foliaceus*, the fish parasite; *Lophopus crystallinus*: a large colony of *Dendrosoma radians*; and *Nassula ambigua*, from Smethwick.

Mr. T. H. Waller, an interesting specimen of "slickensides" of quartzite, from Caldecote Quarry, near Nuneaton; globular phosphate of lime, from South Russia; a section of foraminiferal carboniferous limestone, from North Wales; a section of precarboniferous lava, from the Cheviot Hills, containing hypersthene; a slide of the volcanic dust ejected in the late eruption of Krakatoa, in Java, and of a lava from Montserrat, the trituration of which would produce such dust.

Mr. S. Walliker, a humming bird and a leaf insect from the East Indies; a species of Lepisma, found in cotton-wool from Cyprus, about three or four times as large as the ordinary species.

Mr. C. J. Watson, crystals of selenite, from Shotover Hill, Oxford; minerals from Barmouth; and a large number of photographs of Welsh scenery, taken by himself.

Mr. W. H. Wilkinson, *Lodoicea Seychellarum*, a double cocoa-nut, found only in the Seychelles; Lee-chee nuts, the fruit of *Nephelium Litchi*, from China; *Cactus triangularis*, the prickly pear, from the West Indies; models of an orange and a lemon formed by coating the fruit with copper, and then burning; a number of foliaceous roses, in which the ordinary pink petals were of a green colour; a Canterbury bell, in which the sepals were enlarged and petaloid (blue); the following Lichens from the Highlands of Scotland:—*Cladonia rangiferina*, *C. extensa*, *C. endiviæfolia*, *C. gracilis*, *C. macilenta*, *C. pyxidata*, *C. uncialis*, *Sphærophoron compressum* (rare), *Parmelia physodes* var. *platyphylla* (in fruit, rare), *P. saxatilis* var. *omphalodes*, var. *sulcata* (in fruit, rare), *P. olivacea*, *Pertusaria communis*, *Lecanora tartarea*, *L. parella* var. *pallescens*, *Physcia pulverulenta*, *P. parietina*, *P. furfuracea*, *P. prunastri*, *Usnea barbata*, *Ramalina farinacea*, *R. fraxinea*,—vars. *ampliata*, *fastigiata*, and *canaliculata*, *R. calycalis*, and *Sticta pulmonaria*; *Ricasolia amplissima*, from Oban; the following Lichens, growing on trees, from Blockley, Worcestershire:—*Ramalina fraxinea* var. *ampliata*,—var. *fastigiata*, *R. farinacea*, *Physcia prunastri*, *P. ciliaris*, *Parmelia pulverulenta*, *P. caperata*, and *P. parietina*; and a piece of conglomerate, brought by Mr. S. Walliker from the north of Ireland, on which were growing the following Lichens:—*Ramalina scopulorum*, *Physcia parietina*, *Lecanora subfusca*, and *Verrucaria maura*.

J. MORLEY,
W. B. GROVE, B.A. } Hon. Secs.

BIOLOGICAL SECTION.

There have been ten meetings of this Section during the year, under the presidency of the Chairman, Mr. A. W. Wills, at which there has been an average attendance of 18·8, showing a falling off compared with last year.

Five papers have been read, the titles of which will be found on page xxii.

A large number of specimens has been exhibited, principally botanical, and the meetings have been especially noticeable for the large and interesting displays of fungi, most of which were contributed by our indefatigable friends, Messrs. J. E. Bagnall and W. B. Grove, who have added several new species to both the British and local floras. Mr. Bagnall has also exhibited a number of mosses, lichens, and hepaticæ, some rare and new to the district.

In the zoological department Mr. T. Bolton has exhibited a new capito-branchiate annelid, *Haplobranchus æstuarinus*, and Mr. R. W. Chase some interesting birds.

JOHN F. GOODE, Secretary.

GEOLOGICAL SECTION.

Ten meetings of this Section have been held during the year, with an average attendance of 27.

With the exception of the summer months, papers have been read at every meeting, many of them being very valuable and the result of recent and original investigation; the titles will be found on page xxii.

There has been a decrease in the number of geological exhibits, the principal exhibitors being Messrs. W. J. Harrison, C. A. Matley, and T. H. Waller.

Two geological excursions have been made during the year—on August 18th to Nuneaton, leader, Mr. T. H. Waller; and on September 15th to the Lickey, under the guidance of Mr. W. J. Harrison.

A. H. ATKINS, B.Sc., Hon. Sec.

SOCIOLOGICAL SECTION.

This Section was established on March 20th, 1883, in accordance with Law X., on a formal requisition signed by fifteen members of the Society. It may be pointed out that the intention of the Section is philosophical, rather than distinctly sociological, and that the choice of the name was made to avoid confusion with any other Society.

Mr. Herbert Spencer, who was already an Honorary Vice-President of the Society, expressed his cordial approval of the course of work proposed to be done by the Section, adding some valuable suggestions. It is hoped in time to go through the whole of his works, discussing special points as they arise, and, where practicable, giving illustrations.

At the first meeting Mr. W. R. Hughes was elected Chairman, and Mr. Alfred Hayes Hon. Sec.; but Mr. Hayes, in consequence of pressure of engagements, resigned his office, and on October 4th last Mr. W. Greatheed was appointed to fill the vacancy. The Section has held eight ordinary meetings and four special meetings, the average attendance at the ordinary meetings being 19·2, which has always included several ladies. The enumeration of the work done by the section will be found on page xxii. of this report.

The first meeting was opened by an address from the Chairman. The discussion of Mr. Herbert Spencer's "Essay on Education" was then formally introduced, and was continued during the months of June and July.

Mr. Herbert Spencer's "Principles of Biology" was the next work selected for examination. It was felt that this work was the one most likely to be congenial to the members of the Society. The first chapter, "On Organic Matter," in part I. of the Data of Biology, was ably introduced at the October meeting by Dr. Alfred Hill, and the subject was continued at subsequent meetings by other members. Many interesting microscopical and other illustrations have been kindly given by Mr. J. O. W. Barratt, B.Sc., Mr. W. H. Cox, Mr. W. H. France, Mr. J. Levick, F.R.M.S., Mr. W. P. Marshall, M.I.C.E., and Mr. Rabone, at the various meetings.

A special feature of the Section has been that of the excursions made to local spots rendered famous by great minds. The first of these was made to "George Eliot's Country," on the afternoon of Saturday, 2nd June, under the guidance of Mr. E. W. Badger, when, by the kindness of Mr. C. N. Newdegate, M.P., the fine hall and grounds of Arbury (the Cheverel Manor of "Mr. Gilfil's Love Story") were thrown open to the members. A paper on "George Eliot" was subsequently read at a special meeting of the Section by Mr. Badger, to which friends were invited.

An excursion was also made to "Shakespeare's Country," on Saturday, October 6th, under the guidance of Mr. Rabone, who subsequently read, at a special meeting of the Section, a paper entitled "Some Jottings about Shakespeare and Stratford."

The attendance at these excursions and special meetings was large, averaging nearly fifty members and friends. In the

Chairman's recent interview with Mr. Herbert Spencer he was pleased to approve of the utility of these "outings" in brightening the necessary dryness of an abstract study.

Correspondence has taken place with Mr. M. J. Savage, of Boston, the author of "Evolution and Religion," and of the "Morals of Evolution," which may perhaps tend to a closer union of English and American Spencerians.

In the communications of the Section the embellishment which is familiar to all readers of "Synthetic Philosophy," and which symbolizes the connection of organic and inorganic matter, has been used, by the kind permission of Mr. Spencer, the cost of the woodblock having been defrayed by the Chairman. The Section has received several presents, including a paper on the "Classification of Statistics and its Results," by Mr. Patrick Geddes. It is hoped that during the coming year Excursions may be made to the countries associated with the names of Darwin, Byron, Shenstone, or Landor.

W. GREATHEED, Hon. Sec.

THE LIBRARIAN'S REPORT.

The Librarian is able to report that the Library is in fairly good condition. There is, however, one valuable work missing from the shelves—viz., Yarrell's "Fishes," vol. 1.

The following books have been issued during the year:—Botany, 67; Entomology, 12; Geology, 30; Microscopical, 53; Miscellaneous, 112; Ornithology, 16; Zoology, 55; total, 345. This is an increase of 39 volumes in excess of the issue of last year. The number of members borrowing books during the year has been 69.

The additions to the Library have not been numerous, the funds of the Society being low. The following have been purchased:—

Challenger Report, vol. vii., 4to.
Topographical Botany, 2nd Edition, 1883, Hewett C. Watson, 1 vol., 8vo.
The Colours of Flowers, Grant Allen, 1 vol., 12mo.
History of British Birds, part iii., Seebohm.
Ray Society's vol. for 1882.
Palæontographical Society's vol. for 1883.
Illustrations of British Fungi, parts xi.—xix., M. C. Cooke.
British Fresh-water Algæ, parts iv.—vi., M. C. Cooke.
British Moss Flora, R. Braithwaite, part vii.
Journal of Botany, 1883.
Nature, 1883.
Geological Magazine, 1883.
Annals of Natural History, 1883.
Zoologist, 1883.
Midland Naturalist, 1883.
Entomologist, 1883.
Entomologists' Monthly, 1883.
Science Gossip, 1883.

The following works have been presented to the Library:

List of Specimens of Crustacea in the Collection of the British Museum: 12mo. Presented by Mr. R. W. Chase.
The Age of the Gneissic Rocks of the Northern Highlands. C. Callaway. By the Author.
Smithsonian Report for 1881, by the Washington Government.
Vignettes from the Invisible World. J. Badcock. By the Author.
Catalogue of Serials in the Library of the Mason College. By the College.
Fruits of all Countries. By Mr. F. Mott. Presented by Mr. E. W. Badger.

Presented by the respective Societies:—

Transactions of the Essex Field Club, vol. iii., 1883.
Report of the Peterborough Natural History Society.
Journal of the Northampton Natural History Society and Field Club. Parts .
Proceedings of the Birmingham Philosophical Society. Vol. iii., part 2.
List of Animals in the Gardens of the Zoological Society, 1883.
Report of the Marlborough College, 1882.

J. E. BAGNALL, Hon. Librarian.

CURATORS' REPORT.

The Curators report that the microscopes are in much the same state as they were at the last Report, with the exception that one of the Collins Microscopes has been overhauled by the maker and has just been returned. They recommend to the consideration of the Committee the desirability of purchasing stand condensers for four more of the microscopes.

The suggestion mentioned in their last Report—viz., that new lamps be purchased, has been carried into effect, and the Society is now possessed of suitable lamps.

Two side reflectors have also been added during the past year to the accessories belonging to the Crouch and Swift Microscopes.

They have pleasure to record that the following slides have been presented to the Society during the past year:—

One slide of volcanic dust from Krakatoa, by Mr. T. H. Waller; six slides, four of Echinoderms, and two of the Entozoa, by Mr. W. F. Sharpus, of London; also four slides, made from rocks collected at Oban, by Mr. T. H. Waller.

Mr. C. Pumphrey has also most generously presented to the Society a new oxy-hydrogen lantern, in place of the old one, which is now somewhat the worse for wear.

The Curators wish, in conclusion, to remind the Members of the various Sections of the Society that they are open to receive further contributions of slides towards furnishing the cabinet with microscopic objects.

R. M. LLOYD,
HERBERT MILLER, } Hon. Curators.

Honorary Vice-Presidents.

T. SPENCER COBBOLD, M.D., F.R.S.
T. H. HUXLEY, LL.D., F.R.S.
CHARLES CARDALE BABINGTON, M.A., F.R.S.
HERBERT SPENCER.

Officers for 1884-5.

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Vice-Presidents:
R. W. CHASE. J. E. BAGNALL.

Ex-Presidents (who are Vice-Presidents):
W. GRAHAM. W. R. HUGHES. J. LEVICK. W. SOUTHALL.

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Librarian: W. B. GROVE, B.A.

Curators:
H. J. SAYER AND C. H. SAUNDERS.

Secretary of Biological Section:
J. E. BAGNALL.

Secretary of Geological Section:
J. UDALL.

Secretary of Sociological Section:
F. J. CULLIS.

Honorary Secretaries:
J. MORLEY AND W. H. WILKINSON.

Elected Committee:

J. F. GOODE.
W. HILLHOUSE, PROF., B.A.
C. LAPWORTH, PROF., F.G.S.
W. P. MARSHALL, M.I.C.E.
J. RABONE.
EDMUND TONKS, B.C.L.

LIST OF THE MEMBERS

OF THE

BIRMINGHAM

NATURAL HISTORY & MICROSCOPICAL SOCIETY,

JANUARY, 1884.

Those Members whose names are marked with (P) have been Presidents of the Society; those with (L) are Life Members; those with (C) are Corresponding Members.

To prevent the recurrence of a frequent misunderstanding, Members are reminded that their names are retained on the Society's books and their Subscriptions considered due until notice of resignation has been given to one of the Honorary Secretaries, in writing, according to Laws IV. and VI.

Name.	Address
Abrahall, J.	2, Copely Hill, Gravelly Hill.
Adams, J.	Highfield Road, Harborne.
Albright, G. S., B.A.	The Elms, Park Road, Edgbaston.
Allday, John	The Oaks, Handsworth Wood.
Allison, C. H.	36, Carpenter Road.
Allport, Samuel, F.G.S. *(P)*	The Mason College.
Antrobus, Alfred	Old Chester Road, Erdington.
Antrobus, P.	Church Hill, Handsworth.
Atkins, E.	Woodside, Handsworth Wood.
Avery, Alderman, J.P.	Church Road.
Babington, C. C., M.A., F.R.S. *(Hon. V.P.)*	Cambridge.
Badger, A. Bernard	Oxford Road, Moseley.
Badger, E. W. *(P)*	Office of *Midland Counties Herald.*
Bagnall, Jas. E.	84, Witton Road.
Bailey, T. H.	Plymouth Works, Merthyr Tydvil.
Bain, Rev. W. J.	Bridport, Dorset.
Ballard, J. F.	Melrose, Sidcup, Kent.
Barclay, Thomas	Moseley Road.

Barling, G., M.B. .. .. .. General Hospital.
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Betteridge, J. .. .. .. 36, Suffolk Street.
Bevan, Rev. J. O. .. .. .. 72, Beaufort Road.
Blakemore, J. .. .. .. Oban House, Ladywood Road.
Bland, T. F. .. .. .. High Street, Stourbridge.
Bolton, Thomas, F.R.M.S. .. 57, Newhall Street.
Bowater, W. H. .. .. .. 110, Lodge Road.
Boyden, Rev. H. .. .. .. Pershore Road.
Braendlin, F. A. .. .. .. Oakfield, near Knowle Station.
Brain, R. T. .. .. .. 231, Lozells Road, Handsworth.
Braithwaite, Dr. (C) .. .. The Ferns, Clapham Rise, S.W.
Brittain, Henry .. .. .. George Street West.
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Callaway, C., D.Sc., F.G.S. (C).. Wellington, Salop.
Carter, E. M. .. .. .. 33, Waterloo Street.
Carter, H. J., F.R.S. (C).. .. Budleigh Salterton, Devon.
Caswell, C. B., F.I.C. .. .. 13, George Road, Edgbaston.
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Chase, R. W. .. .. .. 2, Edgbaston Road, Edgbaston.
Chamberlain, R. .. .. .. Westbourne Road, Edgbaston.
Chavasse, T. F., F.R.C.S. .. 24, Temple Row.
Clarke, Ann E., M.D. .. .. 39, Hagley Road.
Clarke, T. .. .. .. 7, Trafalgar Road, Moseley.
Clive, Chas. .. .. .. Barston Hall, near Solihull.
Cobbold, T. Spencer, M.D., F.R.S. (*Hon. V.P.*) .. .. 74, Portsdown Road, Maida Hill, London, W.
Collens, E. .. .. .. Holly Lane, Erdington.
Collett, Harvey .. .. .. West Bromwich.
Collins, F. H., F.L.S. .. .. Church Field, Edgbaston.
Collins, G. .. .. .. Oak Tree Cottage, Prospect Road, Moseley.
Collins, J. T. .. .. .. Church Field, Edgbaston.
Collins, W. W. .. .. .. 55, Balsall Heath Road.
Cond, T. .. .. .. 266, Pershore Road.
Cocksey, J. H. .. .. .. West Bromwich.
Cotterell, Wm., F.R.A.S. .. 17, Park Street, Walsall.
Cottrell, J. .. .. .. 176, Ashted Row.
Cox, W. H. .. .. .. 85, Rann Street, Ladywood.
Cresswell, A. N. .. .. .. 2, York Road, Edgbaston.
Crofts, George .. .. .. The Cedars, Trafalgar Road.
Crompton, Henry D. .. .. Beaufort Road, Edgbaston.
Crosskey, Rev. H. W., LL.D., F.G.S. (*P*) .. .. .. 28, George Road, Edgbaston.
Cullis, F. J. .. .. .. 28, Claremont Road, Handsworth.
Dallinger, Rev. W. H. (*C*) .. Wesley College, Sheffield.
Davis, Geo. E. (*L*) .. .. Belmont, Thorncliffe, Sheffield.
Deane, Rev. G., D.Sc. (*P*) .. Spring Hill College, Moseley.
Davenport, Walter .. .. 183, Heathfield Road.
Derry, F., F.R.G.S. .. .. 31, Upper Hockley Street.
Dewes, H. .. .. .. 19, Duchess Road, Edgbaston.
Dröscher, Dr. .. .. .. Allesley Park College.
Druce, G. C., F.L.S. (C).. .. High Street, Oxford.

Dugard, William	Lower Loveday Street.
Duignan, W. H.	Walsall.
Edmonds, John	General Cemetery.
Enock, F. (C)	Ferndale, Bath Road, Woking Station, Surrey.
Evett, James	The Elms, Handsworth.
Felton, C. F.	Noel Road, Edgbaston.
Fletcher, Dr. Bell (L)	7, Waterloo Street.
Ford, William Henry	Beaumont Terrace, Merridale, Wolverhampton.
Forrest, H. E., F.R.M.S. ..	13, High Street, Shrewsbury.
Fowke, F. (C)	Thatched House Club, St. James's Street, London.
France, W. H.	Sandford Road, Moseley.
Franklin, C. E.	31, Suffolk Street.
Fraser, Dr. J. (C)..	Chapel Ash, Wolverhampton.
Fretton, W. G., F.S.A. (C) ..	Coventry.
Gardner, Rev. J. B.	45, Priestley Road, Camp Hill.
Gibbins, John	13, Arthur Road, Edgbaston.
Gibbons, W. P.	Athol House, Edgbaston.
Gibson, A. H.	39, Bennett's Hill.
Glainville, Miss M. (C)	Albany Museum, Grahamstown, South Africa.
Goode, A. C.	Oxford Road, Moseley.
Goode, J. F.	The Moors, Church Lane, Handsworth.
Goode, Mrs.	The Moors, Church Lane, Handsworth.
Goode, Miss	34, Frederick Road.
Graham, Walter, F.R.M.S. (C)	Ludgate Hill.
Greatheed, W.	9, Burton Crescent, London, W.C.
Green, W. J.	Ivy Cottage, Booth Street, Handsworth.
Greenway, J. F.	28, Wheeley's Road.
Griffiths, A. H.	Thornbury, Woodbourne Road, Edgbaston.
Grove, W. B., B.A.	269, St. Vincent Street, Ladywood.
Grubb, J.	Beaufort Road.
Hadley, F...	Hamstead Lodge, Handsworth.
Hadley, Miss A.	Hamstead Lodge, Handsworth.
Hale, W.	King's Norton.
Hall, A.	Edith Villa, Albert Road.
Hamel, E de (C)	Tamworth.
Handley, E.	Hendra, Church Road, Edgbaston.
Harrison, W. J., F.G.S... ..	365, Lodge Road.
Hassall, T. H.	Balmain House, Trafalgar Road, Moseley.
Heaton, James	Union Passage.
Heaton, George, J.P.	Church Hill, Handsworth.
Heaton, Mrs. George	Church Hill, Handsworth.
Heaton, Harry	Harborne House, Harborne.
Heaton, Alderman, J.P. ..	Courtlands, Edgbaston.
Hiepe, W. L.	65, Villa Road, Handsworth.
Hill, Alfred, M.D., F.C.S. ..	Birmingham.
Hill, J. A., F.R.M.S.	Greystone Lodge, Leamington.
Hill, Frederick	Park Street.
Hillhouse, Professor W. ..	Francis Road. Edgbaston.
Hinks, J.	Buckingham Street.
Hobkirk, C. P. (C)	West Riding Bank, Dewsbury.
Hodgkinson, W. L.	Norwood House, Erdington.
Hookham, George, M.A. ..	Trafalgar Road, Moseley.
Hooper, T...	Wylde Green.
Hudson, R.W.	Bache Hall, Chester.

Hughes, W. R., F.L.S. (*P*) ..	Wood House, Handsworth Wood.
Hughes, Mrs. W. R.	Wood House, Handsworth Wood.
Hutchinson, A. J.	126, Hockley Hill.
Huxley, T. H., LL.D., F.R.S. (*Hon. V.P.*)	4, Marlborough Place, St. John's Wood, N.W.
Huxley, Dr. J. C...	91, Harborne Road.
Iliff, G. M.	26, Temple Street.
Impey, R. L.	Waterloo Street.
Innes, J.	Moseley.
Jermyn, Miss E.	12, Islington Row.
Johnson, Alfred	7, George Street, Parade.
Johnson, Miss	Packwood Grange, Knowle.
Johnstone, George Hope ..	Headingley, Hamstead, Handsworth.
Jones, George, M.R.C.S. ..	Newhall Street—41, Hagley Road.
Kenrick, G. H.	Maple Bank, Church Road, Edgbaston.
Kent, W. Saville, F.L.S., F.R.M.S. (*C*)	Aston House, St. Stephen's Avenue, Shepherd's Bush, London, W.
Ketley, Charles B.	7, Belle Vue Terrace, Smethwick.
Lambert, Streeter	Sunnyside, Ampton Road.
Lancaster, W. J., F.C.S	3, Snowdon Villa, Heathfield Road, Handsworth.
Lapworth, Professor C., F.G.S.	The Mason College.
Leigh, James	King's Norton.
Leitner, Simon	Solihull.
Levick, John (*P*)	89, Lime Tree Villas, Albert Road.
Linn, D. J.	124, Soho Hill, Handsworth.
Littlewood, W.	West Bromwich.
Lloyd, Jordan, M.B., F.R.C.S...	21, Broad Street.
Lloyd, J., M.B.	Coventry Road.
Lloyd, J. H., B.A.	Edgbaston Grove, Church Road.
Lloyd, Wilson	Wednesbury.
Lovett, W. J.	102, Camden Street.
McCowan, W., F.C.S.	Crown Brewery, Cape Hill.
Major, J. L.	The Bhylls, near Wolverhampton.
Mantell, C., jun.	21, Cregoe Street.
Mapplebeck, John E., F.L.S. ..	Hartfield, Moseley Wake Green.
Marrian, J. R.	Adzor House, Lozells Road.
Marrian, Mrs. J. R.	Adzor House, Lozells Road.
Marris, George	Corporation Street.
Marshall, Professor A. M., M.D., D.Sc., M.A.	131, Cecil Street, Greenhays, Manchester.
Marshall, W. P. (*T*)	15, Augustus Road.
Marshall, Mrs. W. P.	15, Augustus Road.
Marston, W. Yorke	Highfield Road, Edgbaston.
Martineau, Edgar	Solihull.
Mason, J.	Bratt Street, West Bromwich.
Mathews, Wm., M.A., F.G.S. ..	Harborne Road, Edgbaston.
Maw, George (*C*)	Benthall Hall, Broseley.
Mayo, R.	Elmshurst, Handsworth Wood.
Miles, George	Vyse Street.
Miller, Herbert	12, Islington Row.
Mitchell, A. B.	213, Hagley Road, Edgbaston.
Mitchell, F. W. V. (*L*)	212, Hagley Road, Edgbaston.
Morley, J.	Sherborne Road, Balsall Heath.
Morton, E...	Wilson Road, Birchfield.
Myers, Rev. E., F.G.S. (*C*) ..	Claremont Hill, Shrewsbury.
Naden, Thomas	14, Temple Street.

Nash, F. W.	Worcester City and County Bank, Colmore Row.
Nelson, William *(L)*	Freehold Street, York Road, Leeds.
Nevill, R. A.	Richmond Road, Handsworth.
Newton, R. A.	Newhall Street.
Norris, Hill, M.D.	Walsall Road, Birchfield.
Norris, R., M.D.	Walsall Road. Birchfield.
North. C.	Selly Oak.
Oliver, J. W.	271. St. Vincent Street.
Organ, Jas.	88, King Edward's Road.
Owen, Lloyd	Newhall Street.
Painter, Rev. W. H. *(C)*	Park Hill, Knowle Road, Bristol.
Panton, G. A., F.R.S.E. ..	95, Colmore Row.
Parsons, C. T.	Norfolk Road, Edgbaston.
Parsons, Mrs. C. T.	Norfolk Road, Edgbaston.
Parsons, Miss Mary	Norfolk Road, Edgbaston.
Parsons, Miss J. C.	Norfolk Road, Edgbaston.
Payton, Councillor H.	Eversley, Somerset Road.
Peacock, E.	11, Devonshire Place, Portland Place, London, W.
Pearson, H. A.	Far Croft, Handsworth.
Pearson, W. H.	114, Colmore Row.
Pemberton, G. Arthur	Manor House, Dowles, near Bewdley.
Pendleton, W.	Church Hill, Handsworth.
Peyton, Edward	Bordesley Works.
Phillips, Wm., F.L.S. *(C)* ..	Canonbury, Kingsland. Shrewsbury.
Pickering, J. W.	St. George's Vineyard. Great Western, Victoria, Australia.
Player, J. H., F.C.S.	31, Calthorpe Road.
Player, J., F.R.G.S.	Chad House. Edgbaston.
Player, W. D.	19, Chad Road, Edgbaston.
Plowright, C. B., M.R.C.S. *(C)*	7, King Street, King's Lynn.
Pointon, A.	Temple Row.
Pope, J.	King's Norton.
Potts, J.	Bennett's Hill.
President of the Royal Microscopical Society *(C)* ..	King's College, London.
Pumphrey, C. *(L)*	King's Norton.
Rabone, J.	Penderell House, Hamstead Road.
Rabone, Mrs. J.	Penderell House, Hamstead Road.
Randall. Rev. Wm., M.A. ..	Handsworth Rectory.
Roberts, T. V.	The Crescent, Murdock Road, Handsworth.
Robinson, C. R.	25, Legge Lane, Graham Street.
Robison, R.	Royal Insurance Company, Bennett's Hill.
Roderick, John	Hanbury Place, Rose Hill, Handsworth.
Rowlands, Joseph	71, Colmore Row.
Ryland, W. P.	Redlands, Erdington.
Saunders, C. H.	Robert Road, Handsworth.
Sayer, H. J.	Cambridge Street.
Schwarz, Dr. G. C. T.	Queen's College.
Sharp, Councillor	397, Bristol Road.
Sharpus, F. W. *(C)*	30, Compton Road, Highbury, London.
Shoebotham, J. H.	Highfield, Hermitage Road, Edgbaston.
Short, R. M.	3, Imperial Cottage, Great Malvern.
Simcox, A.	12, Calthorpe Road.
Simpson, E. *(C)*	24, Grammont Road, Peckham Road, London, S.E.
Simpson, T.	6, Waterloo Street.

Slocombe, J.	Grosvenor House, Hall Road, Handsworth.
Smedley, W. T., F.R.A.S. ..	25, Waterloo Street.
Southall, William, F.L.S. (*P*) ..	Sir Harry's Road, Edgbaston.
Spencer, Herbert (*Hon. V.P.*) ..	38, Queen's Gardens, Kensington.
Spencer, J...	Sandwell Villas, Birmingham Road, West Bromwich.
Spinks, W...	Royal Nurseries, Harborne Road.
Sturge, Joseph	Wheeley's Road.
Symonds, Rev. W. S. (*C*) ..	Pendock Rectory, near Tewkesbury.
Tait, G. W., M.R.C.S.	Knowle.
Tait, Lawson	7, Crescent.
Tangye, G...	Heathfield Hall, Handsworth.
Taunton, Miss F. M.	10, Yew Tree Road, Edgbaston.
Taunton, J. R. C...	116, Bristol Road.
Taylor, Reuben	Colmore Row.
Thomas, Dr. Wynne	8, Harborne Road.
Thomason, George	88, Hagley Road.
Timmins, Sam., J.P.	Hill Cottage, Arley, Coventry.
Timmins, Mrs. Sam.	Hill Cottage, Arley, Coventry.
Timmis, J. M.	18, Rose Hill, Handsworth.
Tonks, Edmund, B.C.L. (*P.*) ..	Packwood Grange, Knowle.
Toon, James	Pershore Road.
Treadwell, John	123, Gough Road, Edgbaston.
Turner, A...	54, Heathfield Road.
Turner, John	6, Stirling Road.
Twamley, C.	Ryton-on-Dunsmore, Coventry.
Twigg, G. H.	21, Summer Hill.
Tye, G. S.	62, Villa Road, Handsworth.
Tyerman, J. (*C*)	Penley, Tregony, Cornwall.
Udall, J.	77, Summer Hill.
Underhill, F., M.R.C.S... ..	263, Moseley Road.
Vaughan, A.	Henley Lodge, Handsworth.
Vicars, J.	47, Hartington Road, Liverpool.
Vize, Rev. J. E., M.A. (*C*) ..	Forden Vicarage, near Welshpool.
Wagstaff, E. H.	1, Waterworks Road, Edgbaston.
Waller, T. H., B.A., B.Sc., Lond.	71, Gough Road.
Walliker, S.	Post Office, Birmingham.
Walton, F. A.	The Friary, Friary Road, Handsworth.
Warden, Chas., M.D.	31, Newhall Street.
Watson, C. J.	34, Smallbrook Street.
Webb, A. J.	High Street.
Welch, Dr. J. B.	Medical Officer of Health for Handsworth.
White, Alderman W.	Sir Harry's Road, Edgbaston.
Whitehouse, W.	Myrtle Villa, Broomfield, Smethwick.
Windle, Bertram, M.D.	General Hospital.
Wilkinson, A. W.	13, Pershore Road.
Wilkinson, Captain	Elmwood, Hamstead, Handsworth.
Wilkinson, Mrs., sen.	Ariston, Hamstead Road, Handsworth.
Wilkinson, Walter	Shobnall House, Handsworth Wood.
Wilkinson, W. H...	Great Hampton Street.
Williams, Francis	Augustus Road, Edgbaston.
Williams, S. D., jun.	Easy Row.
Wills, A. W. (*P*)	Claregate, Wylde Green, Erdington.
Wilson, G. E.	West Hill, Augustus Road.
Woodman, W.	Trafalgar Road, Moseley.
Woodward, C. J., B.Sc., F.G.S.	97, Harborne Road.
Wright, J. H.	Malvern Villas, Soho Hill.
Wright, Richard (*C*)	Holly Bank, Sale, near Manchester.

Wright, T., M.D., F.R.S. (C) ..	Cheltenham.
Wynn, J. C.	Court Oak Road, Harborne.
Yeoman, W. C.	Park Villa, Solihull.
Young, H. G.	240, Upper Street, Islington, London.

ASSOCIATES.

AGE.		
18	Blatch, W. G., jun.	Albert Villa, Green Lane.
18	Dammann, J. F. R... ..	22, Francis Road.
18	Harrison, W. J., jun. ..	365, Lodge Road.
17	Matley, C. A...	19, Godwin Street, Ashted.
18	Saunders, J. V.	137, Birchfield Road.
18	Stone, H.	Cavendish House, Grosvenor Road, Handsworth.
18	Tregilgas, F. J.	3, Windsor Place, Churchill Road, Handsworth.

MEMBERS ELECTED SINCE JANUARY 1st, 1884.

Albright, Arthur	Mariemont, Edgbaston.
Brooks, Miss M.	23, Carpenter Road.
Browett, Mrs. A.	Chad Valley, Edgbaston.
Cooke, Dr. M.C., M.A., A.L.S. (C).	146, Junction Road, London, N.
Fallows, Miss A.	20, Harborne Road.
Levick, Mrs. J.	Albert Road, Aston.
Lowe, J.	66, Broomfield, Smethwick.
Naden, Miss	Pakenham House, Charlotte Road.
Scruton, A.	New Street.
Simkins, J.	Lyncombe, Middleton Hall Road, King's Norton.
Stone, J. B., J.P...	The Grange, Erdington.
Tangye, Edgar	Heathfield Hall, Handsworth.
Taylor, R. C.	Birmingham, Dudley, and District Bank, Colmore Row.
Wilkinson, Mrs. A. W.	43, Pershore Road.

The Treasurer in Account with the Birmingham Natural History and Microscopical Society.

GENERAL ACCOUNT.

Dr.

1883.	£ s. d.	£ s. d.
To Subscriptions, viz.:		
Arrears	34 5 0	
For 1883	118 10 6	
For 1884	10 2 0	
		162 17 6
,, One Life Subscription		5 0 0
,, Donations—		
John Morley	3 15 0	
W. White (Mayor)	3 3 0	
		6 18 0
,, Balance from Excursions—		
1882	10 0	
1883	15 3	
		1 5 3
,, Cash for Bookcase		1 10 0
,, Balance of Apparatus Fund		13 1 10
,, Balance due to Treasurer		25 4 9½
		£215 17 4½

Cr.

1883.	£ s. d.	£ s. d.
By Balance from 1882		28 0 0
,, Books and Binding		37 0 4½
,, Printing, viz.:—		
Reports	35 7 0	
,, Illustrations	1 5 4	
"Naturalist" Illustrations	2 10 8	
Programmes, etc.	6 17 3	
Circulars for Treasurer	1 8 6	
,, for Marine Excursion	1 8 0	
		48 16 9
,, Postage, viz.:—		
Per Hon. Secretaries	9 17 11	
,, ,, Treasurer	1 6 0	
For Excursions	1 16 9	
,, Reports	2 12 6	
,, "Naturalist"	1 0 0	
,, Union of Natural History Societies ...	1 2 0	
,, Sociological Section	1 0 0	
Per Hon. Librarian	1 6	
		18 16 8
,, Subscription to Union of Nat. His. Soc.		3 18 0
,, Rent and Insurance—		
For 1880	7 0 0	
,, 1883	17 11 0	
		24 11
,, Curator's Salary	25 0 0	
,, ,, for Writing	3 0 0	
,, ,, ,, Commission	5 0 3	
		33 0 3
,, Carriage and Petty Expenses		1 3 1
,, Stationery		2 14 10
,, Loss on 1882 Soirée		16 2 2
,, Printing and Postage, and per Secretary of		
Sociological Section	2 12 1	
Less Balance from Excursion	1 0 10	
		1 11 3
		£215 17 4½

Examined and found correct,

HENRY J. SAYER, } Auditors
J. F. GREENWAY, }

February 5th, 1884.

Apparatus Fund.

Dr.	£ s. d.	Cr.	£ s. d.
1883		1883.	
To Subscriptions.	22 1 6	By Lamps	3 0
		,, Two Aquaria	15 0
		,, Diagram Rails and Tables	3 12 6
		,, Sundry Jars, etc., for Marine Excursion	1 12 2
		,, Balance to General Account	13 1 10
	£22 1 6		£22 1 6

The Sum expended by the Society since 1864, in Books, Furniture, and Apparatus, is now £1,080. Subscriptions still in arrears exceed the whole of the outstanding liabilities, including the balance due to Treasurer.

CHARLES PUMPHREY, Hon. Treasurer.

Birmingham Natural History and Microscopical Society.

LIST OF OFFICERS FROM 1864 TO 1883 INCLUSIVE.

*** *THE BIRMINGHAM NATURAL HISTORY ASSOCIATION was founded in* 1858, *and was reconstructed in the year* 1864 *under the present title.*

	PRESIDENT.	VICE-PRESIDENTS.	TREASURER.	SECRETARY.	LIBRARIAN.	CURATORS.
1864	W. R. Hughes, F.L.S.	William Willis .. .. .. Thomas Fiddian	George Heaton	Charles Adcock	A. E. Fardon ..	C. J. Woodward.
1865	W. R. Hughes, F.L.S.	Thomas Fiddian .. .. .. L. Percival	George Heaton	James Hinds, M.B. ..	Thomas Scott ..	E. J. Chitty.
1866	W. R. Hughes, F.L.S.	Thomas Fiddian .. .. .. L. Percival	George Heaton	Thomas Jepheott	Thomas Scott ..	E. J. Chitty.
1867	Jas. Hinds, M.B.	C. T. Parsons .. .. .. W. P. Marshall, C.E.	George Heaton	Thomas Jepheott	Thomas Scott ..	Fras. Fowke.
1868	Samuel Allport, F.G.S. ..	W. P. Marshall, C.E. .. .. W. Mathews, jun., M.A. ..	George Heaton	A. W. Wills	George Crofts ..	Fras. Fowke.
1869	W. P. Marshall, C.E.	William Hinds, M.D. .. .. Edward Myers, F.G.S. ..	George Heaton	A. W. Wills	George Crofts ..	James E. Bagnall.
1870	William Hinds, M.D.	Edward Myers, F.G.S. .. A. W. Wills	Charles Pumphrey ..	Edward Simpson	James E. Bagnall	W. B. Latham. John Morley.
1871	A. W. Wills	J. W. Cotton, F.G.S. .. .. Rev. H. W. Crosskey, F.G.S	Charles Pumphrey ..	W. G. Blatch	John Morley.. ..	James E. Bagnall. G. Sherriff Tye.
1872	Rev. H. W. Crosskey, F.G.S.	Jas. E. Bagnall .. .. .. Rev. G. Deane, D.Sc	Charles Pumphrey ..	W. G. Blatch	John Morley.. ..	R. M. Lloyd. G. Sherriff Tye.
1873	W. R. Hughes, F.L.S.	Rev. H. W. Crosskey, F.G.S. Rev. G. Deane, D.Sc.. ..	Charles Pumphrey ..	W. G. Blatch	John Morley.. ..	R. M. Lloyd. W. Nelson.
1874	Rev. G. Deane, D.Sc., F.G.S.	Edmund Tonks, B.C.L. .. John Morley	Charles Pumphrey ..	W. Wright Wilson, F.L.S.	James E. Bagnall.	J. W. Cotton, F.G.S. Thomas Fiddian.
1875	A. W. Wills	John Morley .. .. Lawson Tait	Charles Pumphrey ..	W. Wright Wilson, F.L.S.	James E. Bagnall.	J. W. Cotton, F.G.S. G. Sherriff Tye.
1876	Lawson Tait, F.R.C.S. ..	Walter Graham .. .. .. Edmund Tonks, B.C.L. ..	Charles Pumphrey ..	C. B. Caswell .. .. John Morley	James E. Bagnall.	G. Sherriff Tye. G. Edmonds.
1877	Edmund Tonks, B.C.L. ..	Walter Graham .. .. .. G. Sherriff Tye	Charles Pumphrey ..	John Morley	James E. Bagnall.	John Levick. W. H. Cox.
1878	Edmund Tonks, B.C.L. ..	Walter Graham .. .. .. E. W. Badger..	Charles Pumphrey ..	John Morley	James E. Bagnall.	John Levick. W. H. Cox.
1879	W. Graham, F.R.M.S.	E. W. Badger.. .. .. .. W. Southall, F.L.S.	Charles Pumphrey ..	John Morley .. .. .. H. E. Forrest	James E. Bagnall.	John Levick. W. H. Cox.
1880	W. Southall, F.L.S., F.R.M.S.	E. W. Badger.. .. .. .. John Levick	Charles Pumphrey ..	John Morley .. .. .. H. E. Forrest, F.R.M.S.	James E. Bagnall.	W. B. Grove, B.A. R. M. Lloyd.
1881	Edward W. Badger	John Levick .. .. T. H. Waller	Charles Pumphrey ..	John Morley .. .. .. W. B. Grove, B.A. ..	James E. Bagnall.	R. M. Lloyd. H. W. Jones, F.C.S.
1882	John Levick, F.R.M.S... ..	T. H. Waller, B.A., B.Sc.. W. G. Blatch..	Charles Pumphrey ..	John Morley .. .. .. W. B. Grove, B.A. ..	James E. Bagnall.	R. M. Lloyd H. Miller.
1883	T. H. Waller, B.A., B.Sc.	W. G. Blatch.. .. .. .. R. W. Chase	Charles Pumphrey ..	John Morley.. .. .. W. B. Grove, B.A. ..	James E. Bagnall.	R. M. Lloyd. H. Miller.

GLACIAL MARKINGS IN THE RED MARL.

By A. H. Atkins, B.Sc.

Read before the Society January 23rd, 1883.

For some time past the attention of local geologists has been directed to the marks of Glacial action in the Midland Counties. Their efforts tend to prove that the traces of the Glacial epoch extend as far south as Birmingham at least, and that either a sheet of ice covered this neighbourhood, or else a number of ice-covered islands lay in the midst of an extensive Glacial sea. As is well known, the most common traces of ice action consist of *roches moutonnées*, scratches on the rocks, and boulder clay containing striated and polished pebbles and boulders. The former evidences are scarcely possible near Birmingham, where all the rocks are too soft to receive or retain such markings. At the Rowley Hills, however, Dr. Crosskey has discovered large blocks of basalt striated in a manner which points to the action of ice.

Of the latter traces—viz., Boulder Clay, etc.—the best section in this locality is to be seen at California, near Harborne, where there is a thick bed of tenacious clay, containing fragments of all sizes most perfectly scratched and polshed, which also show in which direction they have travelled, for among them may be found fragments of basalt, limestone coal-shale, limestone, slate, and in fact almost all the rocks which occur *in situ* between here and North Wales. Patches of a similar clay may be met with in other localities, as, for instance, Washwood Heath and Tysull. In almost every case it is accompanied and interbedded with masses of Drift, and there seems no doubt that these latter beds were deposited at about the same period.

This paper, however, as the title intimates, bears more especially on the traces found in the Red Marl, the uppermost division of the Trias formation.

This bed extends southward from Birmingham to Warwick and Stratford, and consists of marl interstratified with characteristic layers of brown sandstone and white or grey shale. These bands contain in abundance ripple markings, rain-drop impressions, and pseudomorphs of salt crystals, which, together with the beds of rock salt and gypsum which occur in this formation, show that it was deposited in a great continental salt lake, like the Dead Sea of the present era.

The Boulder Clay is not, at first sight, easily distinguishable from the Red Marl, but a close investigation will show that there is often a top layer of clay of very much better quality, commercially speaking, than the Red Marl below; a fact of which the brickmakers of the district are well aware. Mr. W. J. Harrison, F.G.S., first called attention to a section at Small Heath, where the white bands of the Red Marl were contorted in a remarkable manner, as if they had been subjected to an intense grinding action, and this peculiarity I have noticed to be very common in the neighbourhood.

The section, however, to which I especially wish to call attention occurs near Small Heath, at Mr. Sames's brickworks, situated at the junction of Garrison Lane and Cattell Road. When I first saw the pit I put it down as merely a section of red marl, but a closer inspection revealed many points of interest, and that the lower part only is red marl, with the usual bands of white shale. Above this is a layer about three feet in thickness of an unusually hard shale or sandstone, called by the brickmakers *roche*, and surmounting all a bed of very tenacious clay which varies in thickness according to the surface, but in its deepest part is about thirty feet, including about four or five feet of soil and gravel. The dip of the beds is about 5 S.S.E., and they are faulted shortly afterwards against the waterstones, the next lower division of the Trias formation. The fault runs right through the town, extending in fact from Barnt Green to Sutton Coldfield. The hard band is not found elsewhere in the neighbourhood, which is probably owing to the slight dip and the fact that this clay pit is situated on the highest point in the immediate locality. The height is in fact 430ft. above mean sea-level, while the next elevation near is only 420ft., the hard band indeed determining the escarpment which runs for some distance as a steep hill overlooking the whole town of Birmingham. The clay above the hard band contains some of the grey bands, but much twisted and broken. It is of a very different quality from the red marl, and bricks made from it fetch twice the price of those made from the latter.

Dr. A. Hill has very kindly made for me a chemical analysis of the different beds, which I reproduce here :—

	Red Marl.	Hard Band.	Boulder Clay.
Silica	63·07	37·55	54·38
Peroxide of Iron	8·30	4·82	15·65
Alumina	10·54	8·16	16·58
Calcium Carbonate	4·53	25·80	1·02
Magnesium Carbonate	9·05	13·29	7·27
Potash	1·26	3·05	4·47
Soda	0·48	0·04	0·15
Water	3·43	6·99	0·94
	100·66	99·70	100·46

This analysis shows a considerable difference in the percentages of silica, and alumina in the Red Marl and Boulder Clay, when we take into consideration the fact that the samples were taken from the same section, but it is uncertain whether the discrepancy can be attributed to the results of Glacial action. There is a remarkable difference in the proportions of the soluble constituents, which might possibly be caused by the dissolving out of these substances during the rearrangement of the strata. We cannot learn much, however, from a single analysis, but I think if more analyses of the rocks in the district were made, and the results compared, considerable light would be thrown on the mode of their formation and the alterations they have undergone. The most remarkable fact connected with the section, however, is found at the top of the hard band. In removing the top layer of clay the workmen made a sort of platform, which Mr. Harper, the manager, pointed out to me, and kindly had left for my inspection. When the clay is removed the surface of the rock is found to be beautifully smoothed and polished, which appears to me to point very strongly to glacier action. The only other probable cause is the slipping of the clay above, but the very slight angle of dip seems to preclude this. On the whole the difference in the composition of the layers, the contorted strata, and the polishing of the rock surface, indicate the action of ice, and I think a more rigid investigation of the whole district would tend to confirm this theory.

I have brought the subject forward thus early, and in a rather crude form, in the hope that some of the readers of the "Midland Naturalist" may give the results of their researches, or be induced to pay a little attention to the matter. The field is a wide one, and it is probable that many more data may be obtained not only on the Red Marl, but throughout the district, which will help us to complete the history of the Great Ice Age, especially as it affects the Midland Counties.

In conclusion, I may mention that in another neighbouring clay pit, at the Adderley Park Brick Works, the clay above the marl is very tenacious and of good quality, but it contains numerous pockets of sand and pebbles. At this pit also is a curious little fracture in the Red Marl which has raised the grey bands in a sort of pucker about six inches high.

THE FELSPARS.

BY T. H. WALLER, B.A., B.SC. LOND., PRESIDENT OF THE SOCIETY.

Read before the Society, May 22nd, 1883.

Among the minerals of which the so-called igneous or crystalline rocks are made up there appear certain which are distinguished from the others by their hardness, colour, and specific gravity, and which go by the general name of the Felspars. I have, however, found it impossible to formulate a definition which would include them all without giving it such wide limits as to destroy its value. Thus there are silicates of alumina and potash, or of alumina and lime, or of alumina and soda, or of alumina with any two of the other oxides. The ratios of the silica to the bases vary greatly, and the crystalline form is either monoclinic or triclinic, and the specific gravity varies between 2·57 and 2·75.

I have, therefore, ventured to risk the charge of unsystematic procedure, hoping that even if we cannot exactly express in words the definition of the whole group, the differences between the various members of it, and some of the more striking characteristics, may profitably employ half-an-hour this evening, especially as there is, so far as I know, nothing in the case of minerals which answers to the natural system in Botany, and we have therefore to fall back on what we may call a Linnæan system of description.

Beginning, then, with a *concrete* example, and taking a coarse granite,* such as there is on the table before you, we pass over the black mica scales and the transparent glassy quartz grains, and fix our attention upon the opaque white crystalline constituent of which there is so much in the specimen. We observe first of all that some of the fractures are smooth and shining, evidently such as are familiar to us as cleavage planes, and examining them a little more closely we find in any one crystal two sets of them meeting in an edge, so that the crystal can easily be broken up into prisms. The goniometer tells us that the angles of these fragments are right angles, and from this circumstance the mineral has received the name of Orthoclase, as cleaving at right angles. If now we can obtain a crystal separate from the rock and examine its shape more accurately, it becomes evident that the crystallographic system to which we must refer it is the monoclinic; that is, there is only one plane along which we could divide it and have the two parts similar—*i.e.*, only *one* plane of symmetry. If we take a rectangular block of wood and place it on a looking-glass, the reflected image will appear simply a continuation of the block, and the same would be the case whichever of the faces of the block was placed on the glass. There are, therefore, three planes

* From Lamorna, near Penzance. The granite contains very large white crystals of Felspar.

of symmetry parallel to the three pairs of faces. But supposing that in preparing our block one pair of sides had, while still at right angles to the second pair, been inclined at some other angle to the third pair, a little consideration will show that placing the block on the glass again we shall have the reflection as a continuation of the object in only two of the six possible positions—that, therefore, there is only *one* plane of symmetry, and with the block worked to a proper angle this would be a model of our Felspar crystal.

If now we cut slices thin enough to see through, parallel to the two cleavage planes, we shall find some differences between them as to their relation to polarised light. In both cases we find double refraction—that is, if the polarising and analysing prisms are so placed that the field of the microscope is dark (if the prisms are *crossed*, as it is called), the film of crystal will, in both cases, enable light to pass through the second prism. But, now, keeping the prisms crossed, rotate the specimens on the stage. Four positions will be found in which they no longer do this, but become dark like the rest of the field of view. If now these four "extinction" positions are accurately compared with the positions of the Nicols prisms, it will be found that the edge formed by the two cleavages is parallel to the principal planes, as they are called, of these (that is, to the shorter diagonal of the face of the prism) in one case, and inclined to them at an angle in the other. The first of these will be found to correspond with the most perfect cleavage, the other with that in the plane of symmetry. Some of the larger crystals, when examined on the best (or basal) cleavage, will be found to be divided into two parts, shown by the fact that the cleavage on the one side makes a considerable angle with that on the other; and where detached specimens can be observed it will be seen that the appearance is that of two thin individuals, one of them turned round half way with respect to the other, and partly penetrating each other. This is called twinning, and this particular form is the most usual in Orthoclase, and is termed the Carlsbad twin, from a locality where good examples are found. It will be seen that the rotation is not round an axis perpendicular to the faces in contact, but round one lying in it. The laws governing the twinning of crystals show that that plane, being the plane of symmetry, could not be the twinning plane, as it is called, in contradistinction to the plane of composition. It will be seen at once that merely turning these two rough models round on that plane produces no difference in shape, and neither can there be any in physical properties, seeing that these also are the same on both sides of the plane in question.

In thin slices this twinning shows very strikingly by the different appearance of the two halves in polarised light, produced by the different distribution of the optical properties in them. If the section is accurately perpendicular to the plane of composition, although there will be differences of colour in most positions, still both halves will become dark at the same time. This, however, will happen but rarely, but it is important, in view of what we shall find afterwards, to observe that when they do not become dark at the same time the two parts do not extinguish when the dividing line makes equal angles on each side with the principal sections of the Nicols.

We shall often find in these sections a very indefinite extinction—*i.e.*, the whole surface does not become equally dark all over at any possible position of the section, but takes a curious mottled look. The cause of this is not certainly known, but it has been suggested that it is owing to the crystal being compound instead of simple, built up of an extremely large number of very minute ones of another of the group, a potash felspar, but differing from Orthoclase in some important particulars.

Now we shall probably soon find among the colourless, but often rather cloudy grains, which we are inclined, at the first glance, to take for the mineral we have been studying, some which, under the searching test of polarised light, show themselves to be made up of a very large number of fine bands, alternately light and dark, or if the section is thick enough, alternately differently coloured. On rotating this section between crossed prisms alternate bands will be found to *extinguish* together and at a considerable angle at times from the position of extinction of the other ones, and this, even when the lines of junction make at the extinctions *equal angles* with the principal planes of the prisms. This shows that we have to do with a mineral which is not symmetrical (physically) with regard to the plane of composition of the twinning; in fact it will be found that we have here a crystal of what is called the *Triclinic* system, in which, that is, the three axes are *all* inclined to each other, in which, therefore, no plane can be found which will divide the form into two exactly similar parts—no plane of symmetry, in fact. If the block of which I spoke earlier had not had any of its edges rectangular, it would be seen that it was impossible to find any position in which there was not an apparent break between the object and its reflected image when it was placed on the looking glass.

The mineral which we have thus detected is one of the Triclinic or Plagioclase felspars, so called because if we examine the cleavages in a crystal of one of them we shall find that these are no longer at right angles to each other, but enclose an angle, measured over the edge in which they meet, of about 86½°, varying slightly with the different sorts.

The rough models before you are attempts to give visible proof of some of the exterior properties of these minerals, especially in regard to that by which we have detected them in the rock, the multiple twinning. In the first place, we find that, seeing that no face of the crystal is a plane of symmetry, we may, by simply turning one component through half a circle, keeping the corresponding planes together, produce a twinning possible according to the laws of crystals; and, indeed, this is the commonest of all among the Triclinic felspars, and from its prevalence in Albite is called the *Albite* twinning. In most cases this is repeated very many times, and the models show that the result is the production on the surface (it is no longer truly a plane) of easy cleavage of a number of ridges and furrows. These are the cause of the striations visible even to the naked eye on broken surfaces of these felspars which make them frequently easy to distinguish from Orthoclase. In the large crystal in Granite on the table an included grain of slightly different lustre is visible, and a little further observation shows the striæ on it, proving that it is an inclusion of one of the Plagioclases. It is, however, to the more basic rocks, such as Basalts, Dolerites, and Gabbros, that we must go for the most extended presence of these minerals, in contradistinction to the presence of Orthoclase in the acid rocks, such as Granite, Obsidian, and Porphyry. It must not, however, be for one instant supposed that the separation between what we may call Orthoclase and Plagioclase rocks is a sharp one. Almost all rocks which contain felspar contain a triclinic one to a greater or less extent—even Granite, as mentioned above; and on the other hand, Orthoclase is by no means unknown, even in those rocks in which the prevailing felspar is triclinic.

As to the composition of the different species which make up this group, they are naturally divided into three sections: the pure Soda felspar *Albite*, the pure Lime felspar *Anorthite*, and the mixed felspars *Oligoclase*, *Andesine*, and *Labradorite*. It is still a disputed point whether these last three are really definite minerals, or only mixtures in various proportions of the other two. Szabo is convinced, by the examination of many thousands of specimens, by means of their flame reactions, that the series from Albite to Anorthite is a perfectly continous one. On the other hand, other observers consider that the compounds named are definite and invariable, and that differences of composition are at any rate, to a considerable extent, due to the interlamination of felspars of different species. Dana adduces in favour of the latter view, the fact that different felspars are frequently found intercrystallised; that in these cases there is no appearance of indefinite shading of one into the other, but that both keep perfectly and sharply distinct. I exhibit a specimen, showing this in a striking manner. On the other hand, it is quite certain that some of them—*e.g.*, Oligoclase—have definite optical properties, and a tolerably definite composition. But we must confess that variations are decidedly more common and larger than can be very easily accounted for. I may perhaps give an instance—Professor Heddle, in his analysis of Scotch felspars, gives one of an Oligoclase from Lairg in Sutherland. I have made one of a specimen collected by Professor Lapworth, in Sutherland, and find a very complete accordance, except that the potash is a trifle higher and the lime correspondingly lower. On cutting a thin slice parallel to the basal cleavage, the reason becomes pretty certain. The greater part of the mass is Oligoclase, extinguishing at the low angle from the twinning plane which is characteristic of it but interlaminated with it is another felspar, which by its angle of extinction is shown to be Microline. Now this latter is a potash felspar, so that its presence would necessarily tend to increase the percentage of that alkali, and correspondingly diminish the lime. It is much to be regretted that Professor Heddle has not made (or published, if he has made) observations on the microscopical and optical properties of the grand series of felspars analysed by him. They would almost certainly have afforded an immensely improved point of departure for argument as to the actual chemistry of the group.

To determine what felspar we have in a rock is, unfortunately, a very difficult task, at any rate where it occurs in but small-sized crystals. Chemical analysis is very difficult in the case of such small quantities of material as are usually available, and is frequently but uncertain on account of the almost unavoidable admixture of other minerals. But two or three methods have been proposed, and of them I propose to speak, though only very briefly, seeing that to properly elucidate the subject I should have to make more experiments before you than there is time and opportunity for to-night. I the less regret this, as some time ago I read a paper, and showed experiments, on one of the methods mentioned.

This, which is the one elaborated by Dr. Szabo, professor in the Univerisity of Buda-Pesth, is, in essence, a carefully arranged determination of the fusibility in different parts of a Bunsen burner flame of particular (or at least invariable) dimensions, the same operations also serving for the estimation of the percentage of the alkalis by the intensity of the flame-colouration. This method, which can be completely carried out in about a quarter of an hour, if all goes fortunately, enables us to decide at once and easily between Orthoclase, Albite, Oligoclase, Labradorite, and Anorthite, but requires more practice and more careful observation to determine accurately the varying proportions of soda in Orthoclase (in eighteen analyses of Scotch felspar, by Dr. Heddle, this varies between 0·53 and 5·5%), the division of Andesine between Oligoclase and Labradorite, and the occurrences between this last and Anorthite, which have been called Bytownite. The best way is to compare the specimen with fragments of known composition, one on one side of the flame, the other on the other.

Another plan is that of Dr. E. Boricky, depending on the facts that a dilute solution of fluosilicic acid decomposes silicates, and that the fluosilicates of several of the bases which occur most frequently in minerals crystallise in characteristic forms, and so can be detected, after the drying up of the drop of reagent, by means of the microscope. Thus Orthoclase leaves beautiful cubic and octohedral crystals of the Potash salt, and a few hexagonal prisms of the soda one. In the case of Albite the proportion of the two sorts of crystals is reversed.

For the purpose of separating portions of felspar for trial by either of these methods it is very convenient to use the heavy solution of iodide of Hg. in iodide of K. which Sonstedt proposed, and which is now being much used, especially in Germany, to get out the various constituents of a rock for purposes of analysis. The solution can be got of a sp. gr. of just over three, so that felspars and quartz float while augite sinks. By careful dilution quartz and felspars can be then separated, and even Orthoclase, from the Triclinic ones. This is also proposed by Goldschmidt* as a very convenient and very accurate means of obtaining the sp. gr. of the constituent minerals of a rock even when only one or two grains can be detached, for if the dilution be carried so far that the fragment remains suspended anywhere indifferently in the fluid the sp. gr. of the solid and that of fluid must be equal, and may be easily determined in the case of the latter by means of the sp. gr. bottle.

The optical method of determinin what is the particular felspar in a rock is founded on the fact that the position of the optic axes with respect to those of form varies in the different species. Of course Orthoclase is distinguished from the Plagioclases by its monoclinic symmetry—*i.e.*, in a section of a rock some crystal sections will probably be found in which "extinction" happens when the composition line of the twin structure is parallel to the principal plane of one of the Nicols. It is, however, the discrimination of the Triclinic specifics which is so difficult, and in many cases quite impossible. We have to pick out in the section those crystal sections which extinguish at equal angles on both sides the Nicol plane, and then measure this angle in as many cases as we can find. Now symmetrical extinctions only show that the plane of section has accidentally passed through the crystal perpendicular to the twinning plane, and therefore the extinction angle may vary within wide limits, and it is only by noticing the *maximum* angle that we can form any conclusion whatever; † *e.g.*, in trying to determine a felspar a short time ago I found an extinction of 16° on one side and 17½° on the other—*i.e.*, 33½° from one to the other. Now if I had only been able to find this one tolerably symmetrical extinction I could not have told which felspar it was. It would probably not have been Albite, seeing that the angle in that case should not have exceeded 31½°, but I could have gone no further. When, however, I found further angles of 44°, 48°, 53½°, 54°, 56°, 58°, 66°, 71°, 73°, there was enough to assure me of the presence of a very basic *Lime felspar*, and the observation of one grain showing the zonal structure to be presently mentioned with an extinction angle of 48° in some parts and of 82° in others, made the presence of both Labradorite and Anorthite almost a certainty. In this case a large number of observations could be made, and therefore such a degree of probability produced that I was not at all surprised to find the observations quite confirmed by Szabo's flame reactions, some of the grains which I was able to detach being much more fusible than others, and all

* Neues Jahrbuch I., 1881. Beilage Band, p. 179.

† The following table of the angle between the extinction positions of two Twin Lamellæ in the various Felspars may be of service. The section is supposed perpendicular to the plane of twin composition, and the angle given is the maximum observable for each species:—Orthoclase, 0°; Microcline, 36°; Albite, 31½°; Oligoclase, 37°; Labradorite, 62°; Anorthite, 74½° and upwards. In sections parallel to the Basal cleavage:—Microcline, 30°—32°: Albite, 7°—8° Oligoclase, 2°—3°; Labradorite, 10°—14½°; Anorthite, 57°—74°.

showing a low alkali percentage—*i.e.*, the presence of the two most basic Lime felspars. But the essential condition of obtaining any satisfactory result is the possibility of finding *many* symmetrical extinctions, and even then Dr. Becke, who has studied this a good deal, says that the division and discrimination leaves much to be desired, and should only be relied on in default of more certain methods.

The optical method, however, is quite trustworthy and accurate when it can be applied to fragments obtained by cleavage and placed in definite directions in the field of the microscope. But this naturally demands a certain size in the crystals, so that manageable pieces may be detached. As an example, I may mention that in a north country dyke large clear glassy felspar crystals occur, which my friend Mr. Teall determined optically as Anorthite, the determination being fully borne out by a subsequent chemical analysis.

Passing now to the general features, common to all the different species of Felspar, there is not much that is characteristic, at any rate microscopically. According to the rock in which they occur, they are found to enclose the various minerals associated with them, and, in addition, portions of the ground mass or glassy base, where this occurs, and sometimes, though rarely, the so-called water cavities—*i.e.*, little drops of water shut in by the growing crystal. These inclusions are very frequently arranged in bands round the outline of the section of the crystal, showing that during the time it was forming changes of condition took place, and this is also strikingly shown by the Zonal structure, as it is called, even when there are no inclosures to accentuate it and make it visible without polarised light. A crystal showing this typically does not extinguish all over its extent in any one position between crossed prisms, but bands, more or less nearly following the outline of the grain, become dark, and on continuing the rotation, the extinction passes to other bands, showing, according to the optical method mentioned just now, a difference of composition from band to band.

Some felspars are particularly beautiful minerals, on account of the play of colours they exhibit. In addition to the beautiful green amazon stone from various localities, which is remarkable as being a pure Potash felspar, and yet *Triclinic*, we have the Aventurine or Sun Stone of Norway; Oligoclase, with extraordinarily delicate flakes of a mineral which is probably Hematite, and the well-known Labradorite from Paul Island, Labrador, with its exquisite play of blues and greens, which is also due to inclusions in its substance, though the nature of them is at present quite a matter of dispute. Those who went to Oxford the other day saw in the new schools a beautiful piece set in amongst the marbles of the staircase, and in the Museum is a fine slab of considerably larger dimensions. I am sorry that I can show you to-night only small specimens, but there is a case of beautiful polished specimens in the Corporation Art Gallery which will well repay a visit and examination.

The course of the decomposition of these minerals is most generally by the washing out of the alkaline silicates, and the consequent formation of Kaolin when pure, or of Clay when less so. The China Clay industry of Devon and Cornwall is, as you are well aware, an extremely important one, and the processes of washing, settling, and drying are very interesting to witness, not least perhaps as proving the great length of time that fine particles may remain suspended in water, and the beautiful green colour which is produced by the multitudinous reflections from them while so suspended. In some other cases the decomposition of felspar seems to have resulted in its complete removal—*e.g.*, in the so-called Serpentine of Clicker Tor, by Menheniot, near Liskeard, the original presence of felspar is proved by its still existing where it was completely inclosed by the Augite, which is very little, if at all, changed, and by the forms of the spaces where it indented this mineral, but in the Serpentine of the rock there is no trace of it at all. In the change of the Olivine to Serpentine the felspar has utterly disappeared.

In other cases Zeolites and Potash Mica, with the Tridymite form of Silica, result from the decomposition of Orthoclase, while in the case of the Lime felspars, as Labradorite and Anorthite, the curious aggregate called Saussurite, or False Jade, is perhaps as common as any form of alteration product. The analyses show that there is very often a percentage of ferrous oxide or magnesia, which can only be accounted for by supposing a simultaneous alteration of the Pyroxene or Horneblende associated with it, and a mixture of the products.

I have omitted a good many points which would have been of interest if they could have been properly exhibited to you. In particular, I should have liked to have spoken rather more of the different twinning systems prevalent, and of the compound twinnings which produce such curious appearances of gratings in polarised light. The minute crystals, too, in some Obsidians, which have some claim to be thought incipient Orthoclase, and the curious structural peculiarities of some of the massive forms, but this paper, although but superficial and cursory in the treatment of the subject, has already extended to quite as great a length as I can reasonably ask you to listen to, so I will conclude by referring those who wish to inquire further into the subject to—

Geikie's Text-book of Geology.

Green's Physical Geology, where there is a good rèsumé of the optical properties of the various felspars.

Rutley's Study of Rocks.

Bauerman's Systematic Mineralogy, for some information on the crystallography and twinning.

Zirkel's Die Mikroskopische Beschaffenheit der Mineralien und Gesteine.

Rosenbusch's Mikroskopische Physiographie der petrographisch wichtigen Mineralien.

Szábo's Eine neue Methode die Felspathe auch in Gesteinen zu bestimmen.

Boricky's Pamphlet on the method of discrimination by the use of Hydrofluosilicic Acid.

(The last four in German.)

Fouqué and Levy's grand book on Microscopic Petrology "Les Roches Eruptives de la France."

SOCIOLOGY. *

A few remarks seem called for by me on this the interesting occasion of the first meeting of "The Sociological Section," for the study of Mr. Herbert Spencer's system of philosophy. My difficulty is absence of ability and presence of responsibility in introducing so large a subject, and especially the want of necessary time for condensation and co-ordination. In enthusiasm I am second to few.

The *raison d'être* of the Section may be best gathered from the following letter that was addressed unofficially to Mr. Herbert Spencer.

Wood House, Handsworth Wood,
near Birmingham,
19th March, 1883.

Sir,—I hope that you will pardon this intrusion at a time when all your energies are devoted to your *opus magnum*. Any interruption, however trivial, must in many cases be simply an annoyance. But I trust that the exceptional circumstances under which I write may not be uninteresting to you, and my letter shall be as brief as I can make it.

A few gentlemen, several of whom are members of The Birmingham Natural History and Microscopical Society—among the Honorary Vice-Presidents of which we have already the advantage of including your name—have resolved, with the approval of the Society, to form a section to be called "The Sociological Section, for the study of Mr. Herbert Spencer's system."

The proposed Section will consist chiefly of Naturalists and professional men, all of whom are interested in the Synthetic Philosophy, and sincere admirers of its author.

We feel that as the Natural History Society has a very good Biological Library, including your works, together with Microscopes, Specimens, etc., and as its objects are cognate it is the most fitting home for us.

We believe that new members will be drawn to the parent Society on the formation of the new Section, out of which our ranks will be recruited, and that altogether the arrangement is a satisfactory one on both sides.

We hope to make our Section attractive to thinkers who recognise the doctrine of Evolution, and we want to make it successful. If, however, the meetings only give us "a wave of pleasure," that will be something.

Our proposed plan is to meet monthly for eight or nine months in the year, to go through in turn all your writings—reading up, of course, privately in the interim—holding discussions, and having papers thereon.

Not to begin with too abstruse a subject, we think that the consideration of the "Education" may profitably occupy us for May and June, and in the early autumn we hope to commence with "First Principles."

* Abstract of an Address delivered to the Sociological Section of The Birmingham Natural History and Microscopical Society by W. R. Hughes, F.L.S., President of the Section, at its first meeting at the Mason College, Birmingham.—Thursday, 3rd May, 1883.

My object in addressing you is to ask the great favour of your informing me whether you think well of our intention, and if so, can you, if you think fit, kindly give us—at any time that may be convenient to you—the benefit of any suggestions?

We are modest in expecting any marked practical results from the establishment of our new Section, but we all feel "that the character of the aggregate is determined by the characters of the units," and we are content "to see how comparatively little can be done, and yet to find it worth while to do that little."

I have the honour to be, Sir,

Your faithful and obedient Servant,

(Signed) WILLIAM R. HUGHES.

Herbert Spencer, Esquire.

The very valuable and interesting reply received from Mr. Herbert Spencer is as follows:—

38, Queen's Gardens, Bayswater, W., March 20th, 1883.

Dear Sir,—I wish that others who write to me would all assign as good a reason as that given in your letter of the 19th.

The contents of it give me great satisfaction. My aims from the beginning have been directed towards the application of philosophy to the guidance of life, individual and social; and I rejoice to perceive at length a practical recognition of the truth that Sociology must be studied from the evolutionary point of view, and that political conduct can be rightly guided only when a rational theory of Society has been established. I wish you all success in your undertaking, which cannot but result in some good, even if but little.

In respect of suggestions which you invite, I will say only that I think the growth and prosperity of any organisation is bound up with the doing of work of some kind or other. Mere receptivity will not suffice: there must be independent activity. In this case, where the aim is the diffusion of a doctrine, the work may properly take the form of further elaboration of its component truths by further investigation of evidence. Particular points should be taken up by individual members or groups of members, with the view of gathering together evidence bearing on them, and setting forth the conclusions. As you indicate "Education" as one of the first objects to be dealt with, you might, in connection with it take up the alleged relations between ignorance and crime, and education and morality. There is the evidence afforded by the different communities of Europe and America. There is the evidence afforded by different classes in the same community. There is the evidence afforded by different localities in the same community. In each of these inquiries there is ample scope for effort, and great need for it. Various special questions, with the accompanying suggested investigations, will arise in the course of your reading; and my belief is both that you will succeed best as a Society, and will unquestionably do most good, if, along with the discussion of principles, you carry on inquiries concerning the results of conformity and nonconformity to them.

I am, faithfully yours,

(Signed) HERBERT SPENCER.

William R. Hughes, Esq.

P.S.—It occurs to me that for a Biological Society there is a class of questions specially appropriate to be taken up in connection with Sociology—I mean the modification of men's natures consequent upon social conditions. There is a large group of inquiries to be made respecting the effects produced upon the physique by this or that kind of treatment, now tending to kill the feeble, now to preserve the feeble; tending to check this or that disease, or to leave it its free course. There is another large class of questions concerning the mental effects of legislation of this or that kind—the fostering or the repression of this or that sentiment, and this or that intellectual power, and the consequent changes of character and capacity produced in nations by political causes.

Whatever may come of the establishment of this Section, I think you will all agree with me that it is a subject of great gratification to those members who constitute its nucleus that they have been honoured by the approval of Mr. Herbert Spencer in the course that they have taken. It is no small matter that in the midst of most important and absorbing work he should have recognised and encouraged us so warmly and kindly. His letter is in truth an important and original essay. It is very interesting also to state that Mr. Herbert Spencer in a subsequent letter requested to be furnished with a few copies of our formation Circular, which was addressed to the members of the Society. He says, "Some of my American friends have taken like steps over there; and it would be encouraging to them to find this manifestation of sympathy in their aims here also."

Need I say anything of the master himself to those who are his admiring students? Need I say anything of the eminent Englishman living among us at this time, modestly, unselfishly, and devotedly labouring, without State aid or grants from learned Societies, at the gigantic task he has set himself, of working out and co-ordinating a system of philosophy which "he alone of British thinkers has ever attempted"—he who has been recognised by Darwin as "our great philosopher"—by Professor Tyndall as "the apostle of the understanding"—by Professor Huxley as "one of the profoundest of living English philosophers"—and of whom George Henry Lewes "considered it questionable whether any thinker of finer calibre had appeared in our country." Nor are opinions less warm abroad. Professor John Fiske, of Harvard University, the talented author of "Outlines of Cosmic Philosophy, based on the Doctrine of Evolution," states in that work "that in power of psychological analysis Herbert Spencer has been surpassed by no thinker that ever lived, and has been rivalled only by Aristotle, Berkeley, and Kant." Surely these encomiums are sufficient to entitle the author of the Synthetic Philosophy to the profound admiration and respect of all Naturalists who acknowledge the doctrine of evolution, and follow at a distance in the steps of his friend and co-worker, the illustrious Darwin.

But a higher practical tribute to the genius of Mr. Herbert Spencer was paid by the French nation, when not long since the Minister of Instruction had his famous "Essay on Education"—on which alone his claim to fame might fairly rest—translated into French for gratuitous public distribution. Nor must the great American people be forgotten, for they have, I believe, expressed in a more substantial manner their recognition of the value of his writings. The enthusiastic and hearty reception recently accorded to Mr. Herbert Spencer in New York is evidence of the high opinion which the Americans entertain of his worth.

Why do I refer to these matters? Matters which are perfectly well known to, and rejoiced in, by all Spencerians. Simply because I fancy that many who from want of opportunity or inclination or other accidental causes have no made acquaintance with Mr. Herbert Spencer's writings, have sometimes acquired a prejudice against them.

> Was noble man but made ignoble talk.
> He makes no friend who never made a foe.—*Tennyson.*

To use an illustration of his own: "While yet in its nurse's arms, the infant, by hiding its face and crying at the sight of a stranger, shows the dawning instinct to attain safety by flying from that which is unknown and may be dangerous." That illustration, which is doubtless very applicable to later life, is, as you are aware, from the "Education," and I venture to think that if we followed the example of our French neighbours and printed that Essay alone for gratuitous distribution many lives would be annually saved, and that there is not a single person of average intelligence who reads it but would in some way derive benefit from it. Whether we admit it or reject it, it cannot be doubted that Mr. Herbert Spencer's writings are acquiring a wonderful influence in this country, on the Continent, and in America. Scarcely a newspaper or magazine can be taken up but there appears an article which borrows force from his deductions or quotes one of his aphorisms on the doctrine of evolution. "The adaptation of the organism to its environment"—the "egoism and the altruism" —that wonderful description which he gives of life as "the definite combination of heterogeneous changes, both simultaneous and successive, in correspondence with external co-existences and sequences"—or simpler, "the adjustment of internal to external relations"—are familiar in our mouths as household words. If time were not important I should be glad to quote from "First Principles" Mr. Herbert Spencer's views on Religion and Science—from the "Social Statics" his views on progress, and from the "Study of Sociology" his views on government. But these are, of course, well known to most of the members of this Section.

Of the Synthetic Philosophy, that vast system which, commencing with "first principles"—the knowable and the unknowable—carries its students through the principles of Biology, Psychology, Sociology, and Morality (which last and greatest work of all—a portion of which only, "The Data of Ethics," has as yet been published—we most fervently trust its learned and gifted author may live to accomplish), gives a rational conception of the Cosmos, and applies the doctrine of evolution to all the phenomena, organic and inorganic, which go to build up our planet, time also allows me only just to allude to generally; but I think I may paraphrase the words of Mr. Alfred Russel Wallace applied to the author of the "Origin of Species," and say, "that if other principles should hereafter be discovered, or if it be proved that some of his subsidiary theories are wholly or partially erroneous, this very discovery can only be made by following in his (Mr. Herbert Spencer's) steps, by adopting the method of research which he has taught us, and by largely using the rich store of material which he has collected."*

* "Tropical Nature and other Essays," by Alfred Russel Wallace, p. 253. London: Macmillan and Co., 1879.

Perhaps the most effective and appreciative criticism that has ever appeared of Mr. Herbert Spencer's system was that given by the late Professor W. Stanley Jevons, whose untimely death is still fresh in our memories. In an article entitled "John Stuart Mill's Philosophy Tested" in the "Contemporary Review" for November, 1879, he said:—"To me the Spencerian Philosophy presents itself in its main features as unquestionably true; indeed it is already difficult to look back and imagine how philosophers could have denied of the human mind and actions what is obviously true of the animal races generally. . . . . . . Paley pointed out how many beautiful contrivances there are in the human form tending to our benefit. Spencer has pointed out that the Universe is one deep-laid framework for the production of such beneficent contrivances. Paley called upon us to admire such exquisite inventions as a hand or an eye. Spencer calls upon us to admire a machine, which is the most comprehensive of all machines, because it is ever engaged in inventing beneficial inventions *ad infinitum*. According to Mill we are little self-dependent gods fighting with a malignant and murderous power called Nature, sure one would think to be worsted in the struggle. . . . . . According to Spencer, as I venture to interpret his theory, we are the latest manifestation of an all-prevailing towards the good,—the happy. Creation is not yet concluded, and there is no one of us who may not become conscious in his heart that he is no automaton, no mere lump of protoplasm, but the Creature of a Creator."*

"To Monsieur Comte," the author of the "Positive Philosophy," says Mr. Herbert Spencer, "is due the credit of having set forth, with comparative definiteness, the connection between the science of life and the science of society." He maintained that a knowledge of all the facts connected with the growth and development of individual man must be understood before the facts of the growth and development of aggregates of men—in other words, of societies—could be correctly understood. In his classification of the sciences he therefore placed Biology before Sociology.

For a very admirable opinion of the value of the teaching of Sociology under many of its aspects, I cannot resist quoting the observations of one of the most distinguished of living philosophers and exponents of the Doctrine of Evolution. In that memorable Address, which many of us had the good fortune to listen to, from Professor Huxley in the Town Hall on the occasion of the opening of this noble College on the 1st of October, 1880, he said at the conclusion:—"Within these walls the future employer and the future artizan may sojourn together for awhile, and carry through all their lives the stamp of the influence then brought to bear on them. Hence, it is not beside the mark to remind you that the prosperity of industry depends, not merely upon the ennobling of the individual character, but upon a third condition, namely, a clear understanding of the conditions of social life on the

* "Contemporary Review." November, 1879. 'John Stuart Mill's Philosophy Tested, by Professor W. Stanley Jevons,' pp. 537–8.

part of both the capitalist and the operative, and their agreement upon common principles of social action. They must learn that social phenomena are as much the expression of natural laws as any others; that no social arrangements can be permanent unless they harmonise with the requirements of social statics and dynamics; and that in the nature of things there is an arbiter whose decisions execute themselves.

"But this knowledge is only to be obtained by the application of the methods of investigation adopted in physical researches to the investigation of the phenomena of society. Hence, I confess I should like to see one addition made to the excellent scheme of education propounded for the College, in the shape of provision for the teaching of Sociology. For though we are all agreed that party politics are to have no place in the instruction of the College, yet in this country, practically governed as it is now by universal suffrage, every man who does his duty must exercise political functions; and if the evils which are inseparable from the good of political liberty are to be checked—if the perpetual oscillation of nations between anarchy and despotism is to be replaced by the steady march of self-restraining freedom—it will be because men will gradually bring themselves to deal with political as they now deal with scientific questions; to be as ashamed of undue haste and partisan prejudice in the one case as in the other, and to believe that the machinery of society is at least as delicate as that of a spinning-jenny, and not more likely to be improved by the meddling of those who have not taken the trouble to master the principles of its action."

The recurrence of the word politics in Mr. Herbert Spencer's letter and its postscript, and in the preceding reference to it, may possibly lead some to suspect that we are in some sense a political society. Such, of course, is not the case. We are all students of Sociology, and the basis of our formation is as expressed in our circular.

"The Section originated in a wish to unite, for the purpose of mutual help, those who were already students of Mr. Herbert Spencer's system, but were unknown to each other, and to introduce to the Synthetic Philosophy those already engaged in some special biological study, but as yet unfamiliar with the principles common to all departments of Natural History."

The Science of Society admits of very wide generalisations which no other science offers, and it cannot be doubted that perhaps among the many interesting questions arising out of that study, Education, Religion, Politics, Art, Science, and Literature, will all have a share of attention. *Apropos* of this I venture to quote a few of the concluding words of Mr. Herbert Spencer to his work on the study of Sociology. He says:—"And here let me point out distinctly the truth already implied, that studying Sociology scientifically leads to fairer appreciations of different parties, political, religious, and other. The conception initiated and developed by Social Science is at the same time Radical and Conservative—Radical to a degree beyond anything which current Radicalism conceives; Conservative to a degree beyond anything conceived by present Conservatism."*

And he goes on to point out at length—which I must not stay to trouble you with—that when there has been grasped the truth that Societies are products of evolution, then there will be realised a proper conception of such Societies, and that as Mr. Herbert Spencer says, "thus the theory of progress, disclosed by the study of Sociology as science, is one which moderates the hopes and the fears of extreme parties."

Mr. Herbert Spencer has over and over again insisted on the necessity of scientific culture in general as a preparation for the study of Sociology, and above all culture of the Science of Life. He says: "This is more particularly requisite because the conceptions of continuity, complexity, and contingency of causation, as well as the conception of fructifying causation, are conceptions common to it and to the Science of Society. It affords a specially fit discipline, for the reason that it alone among the sciences produces familiarity with these cardinal ideas—it alone presents the data for them in forms easily grasped, and so prepares the mind to recognise the data for them in the Social Science where they are less easily grasped though no less constantly presented. . . . . The Science of Life yields to the Science of Society certain great generalizations, without which there can be no Science of Society at all."†

It seems to me most appropriate that in Birmingham—whose motto is "Forward" and whose progress has ever been in harmony with it once the home of Priestley, the discoverer of oxygen, one of the early pioneers of Evolution, and that in connection with a Natural History Society like ours, the oldest scientific society in the town, which has made Biology one of its principal studies, and which offers certain special facilities as regards its Library and appliances, there should be established a Section for the study of Sociology.

(1.) As regards the town, I submit from numerous circumstances which I will proceed to set out: its special suitability as a centre for the study of a somewhat advanced type of Society. From its peculiar topographical position in almost the central part of England, situated on the New Red Sandstone, at an average altitude of 450ft. above the mean sea-level (*a*) of undulating surface, covering a large area, and not

(*a*.) According to Dr. Hill, F.I.C., the Medical Officer of Health for Birmingham, in his Report of the Health of the Borough for 1881:—"The elevation of the borough, that is its height above the mean level of the sea, varies between 310 and 600 feet, the lowest point being at Saltley, and the highest at Edgbaston. This lofty position is in many respects a considerable advantage, especially when associated, as it is in the case of Birmingham, with a porous soil consisting of the upper division of the Bunter or Mottled Beds of the Trias or Upper New Red Sandstone."

* "The Study of Sociology," ninth edition, p. 394, 1880.

† "The Study of Sociology," ninth edition, p. 322, 1880.

generally overcrowded (*b*), salubrious (*c*), and enjoying an immunity from any serious and persistent class of epidemics;—contiguous to a geological field of exceptional interest, and to a country remarkable for its beautiful and varied scenery, its botanical richness, and its fertile agricultural produce;—in a county rendered famous by one of the greatest poets that any age has ever witnessed;—in a scene of developments in mechanical science with which are associated the names of James Watt, Matthew Boulton, and other worthies who have laid the foundation of the world's prosperity;—in a scene of art manufactures and industries, of beauty and utility, made everywhere famous by the works of Chance, and Elkington, and Gillott, and Hardman, and Mason, and Tangye, and Winfield, and hosts of others;—from the town being independent of any specific forms of trade such as cotton, woollen, etc., and not subject to recurrent panics or waves of depression arising out of or common to those specific forms of trade;—from the many and varied kinds of manufactures and trades which the town possesses, involving commercial relations with all parts of the globe;—from the facilities that these several manufactures and trades give for acquiring independence of position, and with it independence of character and thought;—from the town being within easy access of the Metropolis, but not in any way overshadowed by it, and particularly from its constituting the centre of an elaborate plexus of railway ramification, affording free and rapid communication with all parts of the Kingdom, and as a consequence bringing with it a varied and abundant food supply (*d*); from the drainage of the town being good (*e*);—from its local water supply being both wholesome and plentiful;—

(*b*.) Mr. Hughes submitted a table showing the average number of persons per acre in four large towns, as follows, for the year 1881:—Birmingham, (incorporated 1838) 47·78; Leeds, (1661) 14·33; Liverpool, (9th King John) 106·1; Manchester (1838), parliamentary limits, 61·90. Mean, 57·51.

(*c*.) Mr. Hughes submitted a table, compiled from Dr. Hill's Report above referred to, exhibiting the mean death-rate per 1,000 persons living in nine large towns for the nine years from 1872 to 1881, both inclusive, as under:—London, 22·56; Liverpool, 27·77; Birmingham, 23·18; Manchester, 28·07; Leeds, 24·34; Sheffield, 23·57; Salford, 27·37; Newcastle, 24·61; Norwich, 22·57. Mean of twenty large towns for the same period, 23·72.

(*d*.) A single illustration will suffice. Before the railway system was inaugurated, fish, as an article of diet, must have been (except to the wealthy) comparatively rare in Birmingham. Now, from its central position, the town has one of the most abundantly and variedly-supplied fish markets in the kingdom. At a recent public enquiry before an inspsetor from the Local Government Board, the Chairman of the Markets and Fairs Committee of the Corporation (Mr. Councillor M. J. Hart) stated that the estimated annual quantity of fish passing through the hands of the wholesale dealers in Birmingham was about 100,000 tons, and its estimated value about £1,000,000.

(*e*.) The method of treating the sewage not only of Birmingham but also of the surrounding districts within the water-shed of the River Tame, including an area of about 47,000 acres, by precipitation by lime in tanks, coupled with purification by passing the effluent through the land appears to be the best yet devised. About thirteen million gallons of sewage is so treated daily.

from frequent immigration from other and distant localities;—from the town being undemoralised by antiquities or obsolete charities;—from the number, variety, and excellence of its educational, scientific, and literary institutions (*f*);—from the perfect freedom which all religious communities possess, and the vitality displayed by them;—from the active and energetic political and civic life which has always characterised its citizens;—from the remarkable development in almost every direction which the town has exhibited during the present century (*g*);—from the number and variety of its annual exhibitions (*h*) inducing a healthy spirit of emulation both local and distant (witness the Exhibitions of Paintings and Industrial Arts, the Agricultural Exhibition, and the Exhibitions of Domesticated Animals;—the Horticultural Exhibitions, including specialities in certain flowers, some of which Exhibitions originated here, or are of acknowledged excellence);—from the large spirit of voluntary beneficence displayed by its inhabitants of all creeds and classes (witness the annual Hospital Sunday and Saturday collections (*i*) for the Charities of the town, both of which originated in Birmingham);—from the recreations of the people being both intellectual (witness

(*f*.) The Birmingham and Midland Institute was established in the year 1854, since which period upwards of 40,000 students have attended its Scientific, Literary, and Educational Classes, exclusive of the attendance at the Weekly Lectures in Session. The Mason Science College, which was founded by the generosity of the late Sir Josiah Mason so recently as the year 1880, has now (1883) more than 300 students. Both these institutions are open to male and female students.

(*g*.) Mr. Hughes submitted a table showing that the population, which was 4,000 in 1690, had grown to 73,670 in 1801, and had increased at an average rate of about 24 per cent. in each decennial period from 1801 to 1851. At 1851 it stood at 232,841, and at 1881 it stood at 402,296. Speaking generally, the population had increased about a hundred-fold in two hundred years.

(*h*.) Mr. W. P. Marshall, M.I.C.E., has called my attention to the fact that "The Bingley Hall Exhibition of Manufactures," which was organised by the Local Committee of the British Association at Birmingham in 1849, as a special local attraction for the members of the Association, was the parent of the Great Exhibition of 1851. Prince Albert, who had then the subject of an International Exhibition actively in his mind, having heard of this Birmingham Exhibition, made a special visit to the Exhibition, 12th November, 1849 travelling down from London by a special train in 2½ hours, and he expressed himself greatly pleased and interested, making a close inspection and questioning the manufacturers about the work exhibited. It was understood he was greatly struck by the successful accomplishment of the exhibition, and that the result gave aid of importance in reference to the suggested Great International Exhibition of 1851.

(*i*.) The "Hospital Sunday" Annual Collections,—for the suggestion which led to their establishment the town is indebted to the late Mr. Thomas Barber Wright,—were commenced in the year 1859, since which period the sum of £109,564 has been paid over (subject to a nominal deduction for expenses) by the Committee towards the support of the medical charities of the town. The "Hospital Saturday" Annual Collections were subsequently established, on the suggestion of Mr. J. Samson Gamgee, F.R.S.E., in the year 1873, since which period the sum of £44,112 has been paid over by the Committee for the same purposes.

the triennial Musical Festivals (*j*) of European celebrity, the Free Libraries, and the Art School) and physical (*k*) (witness the numerous athletic and similar clubs);—from the fact that the extremes of wealth and poverty are not so marked as in many large towns, but that the number of thriving artizans is more numerous (witness the large number of voters on the register as compared with other large towns) (*l*); —most especially from the conspicuously-characteristic earnestness with which work of all kind is undertaken in Birmingham;—and from a number of analogous factors all of which have their influence, I cannot help—after eliminating to the best of my ability all necessary bias—arriving at a conclusion that, while possessing greater differentiation in its inhabitants as regards trades and occupations than those of many other towns, Birmingham also presents unusual advantages for the physical, intellectual, and moral development of its citizens. Its development is of a type peculiar to a large industrial organization, and is in marked contrast to that kind of development which would obtain under a military, or ecclesiastical, or agricultural organisation. In other words, the progress of the town is quite in accordance with the laws of evolution. It illustrates in a large sense the adaptation of the organism to the environment. Many Sociological generalizations made here may, I think, therefore be regarded as typical and unique. And as many of the factors that I have enumerated act and re-act, it follows that Birmingham has most important influence in the work—both immediate and remote—to which it puts its hand.

It would take up too much of your time for me to mention many illustrations. I just allude to one or two that occur to me. From an educational point of view Birmingham, by its Education League,

(*j*.) The Birmingham Musical Festivals (held triennially) were established in the year 1768 for the benefit of the General Hospital, in aid of which noble charity the managers had paid over up to the year 1882 the sum of £116,576. From a musical-art point of view their influence has been considerable. The "St. Paul" and the "Lobgesang" of Mendelssohn were given in 1837 and 1840, and the immortal "Elijah" was specially written for Birmingham, and produced at the Festival of 1846, under the conductorship of its author. The "Eli" and "Naaman" of Costa in 1855 and 1864, and the "Redemption" of Gounod in 1882, were specially written for these Festivals, and produced under the conductorship of their respective authors. Numerous minor works of importance have also been written for or first produced at these Festivals.

(*k*.) The Volunteer movement, which has always been well supported in Birmingham and the surrounding districts, would seem to be a "co-ordination of the antagonistic elements. The volunteer in time of peace follows his duties as a citizen, but in the event of war is prepared to take up arms and defend his country.

(*l*.) Mr. Hughes submitted a table showing the average number of Parliamentary and Municipal Electors in four large towns for the three years ended 1883, as under: Parliamentary Electors—Birmingham, 63,693; Leeds, 50,179; Liverpool, 62,898; Manchester, 54,861;—mean, 57,908. Municipal Electors—Birmingham, 74,392: Leeds, 58,422; Liverpool, 70,675; Manchester, 58,899;—mean, 65,597. Percentage of Parliamentary Electors to population—Birmingham 15·83; Leeds, 16·23; Liverpool, 11·40; Manchester, 13·93;—mean, 14·35. Percentages of Municipal Electors to population—Birmingham, 18·49; Leeds, 18·90; Liverpool, 12·79; Manchester, 14·96;—mean, 16·29.

was, for the suggestion from which originated this movement, in advance in obtaining the establishment of Board Schools; from a political point of view the action of Birmingham on the passing of the Reform Bill of 1832 was most important, and must not be overlooked; nor its action subsequently in political matters. The example of beneficence in Birmingham as regards the Hospital Sunday Collections has spread to other large towns, and even to the Metropolis. The action of its Corporation as to the issue of a funded stock, and in many other forms of its work, has been adopted as a model by other Corporations. In any movement having for its object the advancement of the civil and religious freedom of the people, Birmingham has usually been in advance.

Since the foregoing was written, my friend Mr. Greatheed has called my attention to a recent most interesting lecture by Professor Lapworth, F.G.S., of the Mason College, entitled "The Geology of the Midlands." After pointing out the advantages resulting from the insular position of England, and the "perfect mine of wealth" contained in her rocks, he further showed the contrast between the scenery and strata of the Eastern and Western Counties, the peaceful nature of the former, and the harsh and rugged character of the latter, and finally pointed out that "in the Midland District we stood midway between these two types—half-way down the great geological scale—that there was one district where these two kinds of rocks were to be met together, and there was only one large town where they could be seen. The district was the Midland District—the town was Birmingham."

Apropos of the same generalization, Mr. Greatheed has directed my attention to two recent articles in the *Rèvue des deux Mondes** attributing George Eliot's powers partly to her Midland sympathies. Indeed George Eliot herself, in reply to some questions of an American lady, writes:—"It is interesting, I think, to know whether a writer was born in a central or border district—a condition which always has a strongly determining influence. I was born in Warwickshire, but certain family traditions connected with more northerly districts made these districts a region of poetry to me in my early childhood."†

I feel that I have only touched on the foregoing points very crudely and roughly, but I think Sociological students will accept some of the conclusions, and that they will probably agree with me that no more generally interesting field for the study of Sociology exists than the town in which we live.

(2). As regards the Natural History and Microscopical Society, of which our Section is now a unit, I question very much if there are many local Societies like it which have held their own for something like a quarter of a century, and have had their influence, as ours has, in disseminating a taste for Botany, Zoology, Geology, and Microscopy.

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* *Revue des deux Mondes*, Mar. 1, 15, 1883, Art. "George Eliot," par M. Emile Montegut.

† Mathilde Blind's Life of George Eliot, 1883, page 12.

Here at our meetings, irrespective of class distinction, the professional man, the merchant, the manufacturer, the clerk, and the working-man gather together on common ground—that common ground being the study of Nature. There is no distinction, either of politics or of religion, or even of sex! I well remember the time when, except among the medical profession, a microscope was a rarity in the town, and now at the Annual Conversaziones of this Society alone we can number a hundred!

The growth and development of our Society has been remarkable. Originally consisting of a few enthusiastic naturalists, who met in a small back room in the Midland Institute—by the courtesy of the Council of that body—it now numbers nearly four hundred members, and has acquired a distinction of which we may be justly proud. The annual contribution to its funds is almost nominal, but by united efforts our Library numbers on its shelves the most important works in Natural History and Microscopy. Our Microscopes are of the best that can be acquired. By our exertions the Midland Union of Natural History Societies was established in 1878, comprising nearly thirty local Societies within a radius of sixty miles, and an aggregate of 2,500 members, having a Journal of its own—"The Midland Naturalist." The annual gatherings in neighbouring towns have been highly successful, and the foundation of the "Darwin Medal"—in honour of the distinguished Naturalist who favoured our Society by accepting the office of an Honorary Vice-President, given annually for the best original Essay or Paper in Biology, Geology, or Archæology—is a noteworthy feature. The last medal was awarded to two of our Members, Professor A. Milnes Marshall, D.Sc., and Mr. W. P. Marshall, M.I.C.E., for researches on the *Pennatulida* (Sea Pens, etc.) obtained at Oban during the Dredging Excursion of 1881. And here I should like to remark that we are proud to have reckoned among the early Members of our Society Mr. Grant Allen, who has since risen to fame as an evolutionist. On all these grounds I submit that our Society is a Sociological factor of importance, that its influence acts and interacts, and that the establishment of a Sociological Section as part of its organization is a step in the right direction.

The highly suggestive and valuable letter with which Mr. Herbert Spencer has favoured us makes it almost presumption in me to offer any suggestion as to the work of the Section, but reverting for a moment to that passage in his letter in which he says:—"As you indicate *Education* as one of the first objects to be dealt with, you might in connection with it take up the alleged relations between ignorance and crime, and education and morality"—I would venture to suggest in connection with this subject that it would be most interesting and valuable to compare the classified results of Criminal Statistics for a given period of years before the working of the School Board in Birmingham and in other towns with the corresponding period since the School Board has been in existence. And with it I would also suggest the taking note of the recent labours of the Health

Committee of our town, resulting in a diminished death-rate, as compared with that of other large towns, and concurrently with it a possibly higher standard of general health. The labours of the Baths and Parks Committee in opening additional baths, parks, and recreation grounds would also tell as factors. In one of his works (I forget which, at this time) Mr. Herbert Spencer suggests that it would be most interesting to ascertain among the criminals in a gaol how many of them had been in the habit of taking a bath! The opening of a public park or recreation ground in a district would not only have remote influence in diminishing crime in that district, but immediate influence in adding to the health of that district. Morally and intellectually the opening of a Free Library in a district would be a most important factor of progress. The labours of the Improvement Committee of our town having charge of the Artizans' Dwellings Scheme in removing unfit and unsanitary dwellings, and opening up spaces for oxygenation and freedom of transit, are all interesting factors. Probably, also, the closing of unnecessary houses for the sale of intoxicating drinks, and the opening of coffee houses in a district, act as Sociological factors of progress.

We all remember the famous illustration in the "Origin of Species" (showing the complex relations of all animals and plants to each other in the struggle for existence), of the large and extremely barren heath, part of an estate of a relative of the author, in Staffordshire, of which several hundred acres, of exactly the same nature, had been enclosed twenty-five years previously, and planted with Scotch fir. "The change in the native vegetation of the planted part of the heath was most remarkable, more than is generally seen in passing from one quite different soil to another, not only the proportional numbers of the heath-plants were wholly changed, but twelve species of plants (not counting grasses and carices) flourished in the plantations, which could not be found on the heath. The effect on the insects must have been still greater, for six insectivorous birds were very common in the plantations, which were not to be seen on the heath; and the heath was frequented by two or three distinct insectivorous birds. Here we see how potent has been the effect of the introduction of a single tree, nothing whatever else having been done, with the exception that the land had been enclosed, so that cattle could not enter."*

Another wonderful instance of the relation between cause and effect is mentioned in the "Data of Ethics," and proved by direct experiment. "Making such arrangements that the bile-duct of a dog delivered its product outside the body, Claude Bernard observed that so long as he petted the dog and kept him in good spirits secretion went on at its normal rate; but on speaking angrily, and for a time so treating him as to produce depression, the flow of bile was

* "The Origin of Species," by Charles Darwin, M.A., F.R.S., etc., 4th ed., 1866, pp. 81, 82.

arrested."* And the talented author, further illustrating the relation between cause and effect, mentions that "In the normal order, pleasures great and small are stimulants to the processes by which life is maintained. Among the sensations may be instanced those produced by bright light. Sunshine is enlivening in comparison with gloom—even a gleam excites a wave of pleasure; and experiments have shown that sunshine raises the rate of respiration: raised respiration being an index of raised vital activities in general." †

I feel sure you will all agree with me that if instances of the kind adduced—and their number might be increased to an almost illimitable extent—have weight from a Biological point of view, the factors of progress I have previously alluded to must have weight from a Psychological and Sociological point of view in the question under consideration.

Ladies and Gentlemen, I feel that I have exhausted too much of your time and trespassed too much on the ground of my colleagues in this evening's work. Permit me to express the hope that the interest and kindly feeling which has characterised the establishment of our new Section may continue and develop, and that the Section itself may do good work, bearing in mind Mr. Herbert Spencer's precept "that the growth and prosperity of any organization is bound up with the doing of work of some kind or other. Mere receptivity will not suffice, there must be independent activity;" and that it may benefit the parent Society by an increase of new members who may be attracted by the opportunity thus afforded of discussing any object that may arise in connection with the Doctrine of Evolution as illustrated in Mr. Herbert Spencer's writings. I am sure the Society is to be congratulated on having secured the co-operation of our talented and devoted hon. sec., Mr. Alfred Hayes, B.A., and of the friends whom he has introduced. We shall endeavour to make our meetings interesting, and where practicable there will be illustrations. The excursions "to local spots rendered famous by great minds" will be a relief to harder work, as well as a means of bringing together those of us who think alike. In his famous address to the Americans on the occasion of the farewell banquet, Mr. Herbert Spencer wisely says:—"In brief I may say that we have had somewhat too much of the gospel of work. It is time to preach the gospel of relaxation."

I have to express our warmest thanks to those who have taken an interest in the new Section, and especially I would mention the support we have received from distant localities, notably Wolverhampton, a most important town, possessing many of the characteristics belonging to Birmingham, and yet differing from it in some respects.

A few words of caution may be necessary for us in our progress, and here again I must quote from Mr. Herbert Spencer. "It is (he says)

* "The Data of Ethics," by Herbert Spencer, 1879, p. 89.

† "The Data of Ethics," by Herbert Spencer, 1879, p. 89.

always the tendency of discipleship to magnify the effect of the master's teachings; and to credit the master with all the doctrines he teaches."* And further—"The advocates of a cause usually overstate their case." One of the chief teachings of "The Study of Sociology" is to eliminate the various forms of bias that affect accurate Sociological generalizations. To members of this Section, the mere mention of these aphorisms of the Author of the Synthetic Philosophy—on whose rich stores I have drawn so largely—will suffice, for *they*, happily, do not come within the category of those of whom Mr. Herbert Spencer says that "only by varied iteration can alien conception be forced on reluctant minds." †

Of the Doctrine of Evolution as set forth in Mr. Herbert Spencer's writings, and in the works of Darwin, Huxley, Tyndall, Ernst Haeckel, and others, I need say nothing to an assembly of Naturalists. So far back as 1873 the late Sir Wyville Thomson, whose name will ever be associated with the origin and development of the "Challenger" work, wrote, "I do not think that I am speaking too strongly when I say that there is now scarcely a single competent general Naturalist who is not prepared to accept some form of the doctrine of evolution."‡ Able writers, such as the late Mr. Walter Bagehot in his "Physics and Politics," have applied it in other directions, and others are following the example.

Its most bright, encouraging, impressive, hopeful, and even sublime aspect is that the "process of modification upon modification which has brought life to its present height must raise it still higher,"§ and that the most particular ways "in which this moving equilibrium, this further evolution, this higher life, this greater co-ordination of actions, may be expected to show itself, will be in intelligence and morality."

Regarding intelligence, Mr. Herbert Spencer says: "There is ample room for advance in this direction, and ample demand for it. Our lives are universally shortened by our ignorance. In attaining complete knowledge of our own natures and of the natures of surrounding things—in ascertaining the conditions of existence to which we must conform, and in discovering means of conforming to them under all variations of seasons and circumstances—we have abundant scope for intellectual progress."**

Regarding morality—that is, in greater power of self regulation—Mr. Herbert Spencer says: "Right conduct is usually come short of more from defect of will than defect of knowledge. To the due co-ordination of those complex actions which constitute human life in its civilised form, there goes not only the pre-requisite—recognition

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* "The Data of Ethics," by Herbert Spencer, 1879, p. 6.

† "Essays," 2nd series, page 60.

‡ "The Depths of the Sea," by C. Wyville Thomson, F.R.S., 1873, p. 9.

§ Herbert Spencer. 'Postscript to American Address.' "Contemporary Review," January, 1883.

** "Principles of Biology," vol. ii., p. 496.

of the proper course; but the further pre-requisite—a due impulse to pursue that course. And on calling to mind our daily failures to fulfil often-repeated resolutions, we shall perceive that lack of the needful desire, rather than lack of the needful insight, is the chief cause of faulty action. A further endowment of those feelings which civilisation is developing in us—sentiments responding to the requirements of the social state—emotive faculties that find their gratifications in the duties devolving on us—must be acquired before the crimes, excesses, diseases, improvidences, dishonesties, and cruelties, that now so greatly diminish the duration of life, can cease." *

A gifted poet of our day, who is essentially the Poet of Evolution—the author of the "Light of Asia"—has caught the spirit of the master, and has given in that remarkable and beautiful work a picture of evolution in lines that cannot fail to be appreciated by all who recognise its operations:—

. . * * * *

Marking—behind all modes, above all spheres,
Beyond the burning impulse of each orb—
That fixed decree at silent work which wills
Evolve the dark to light, the dead to life,
To fulness void, to form the yet unformed,
Good unto better, better unto best,
By wordless edict; having none to bid,
None to forbid; for this is past all gods
Immutable, unspeakable, supreme,
A Power which builds, unbuilds, and builds again,
Ruling all things accordant to the rule
Of virtue, which is beauty, truth, and use.
So that all things do well which serve the Power,
And ill which hinder; nay, the worm does well
Obedient to its kind; the hawk does well
Which carries bleeding quarries to its young;
The dew-drop and the star shine sisterly,
Globing together in the common work;
And man who lives to die, dies to live well
So if he guide his ways by blamelessness
And earnest will to hinder not but help
All things both great and small which suffer life.†

NOTE.—By the kind permission of Mr. Herbert Spencer, the Sociological Section is allowed to use on its Proceedings the Device at the head of this Address, which has been impressed at the side of the binding of the volumes of the Synthetic Philosophy since their first issue. The Device appears to indicate the evolution of life. Beneath are the crystals of the volcanic rocks which underlie all creation. Superimposed is the alluvial soil and recent mould. Springing from the latter are two forms of vegetable life—a Cryptogam (non flowering) and a Phenogam (flowering) plant respectively. The last is a Dicotyledon, the highest form of vegetable life. This appears in bud, leaf, flower, and fruit. Creeping up and feeding upon the flowering plant is a larval form of invertebrate life (caterpillar); suspended from the central portion is the *pupa* (chrysalis), and resting upon and crowning the flower is the *imago* (perfect insect.—W. R. H.

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* "Principles of Biology," vol. ii., p. 497.

† The "Light of Asia." By Edwin Arnold, C.S.I. 9th ed., 1882, pp. 169, 170.

CREMATION.

BY W. H. FRANCE.

Read before the Society October 16th, 1883.

We have it on very old authority that "there is nothing new under the sun;" and though from his ability to re-arrange the forms and combinations of matter, presumptuous man is frequently tempted to exclaim, "Here is something new," all he can do is to transpose substances into new forms, as by the transposition of the alphabet, words of endless variety are produced. Though he use the earth as a ball on which to wind his telegraphs and railways, he works with nothing new, or which did not exist before his own form was evolved from pre-existent matter. He can facilitate, and in some ways he can also retard, that which Nature is constantly doing, namely, changing the forms of matter by decomposition, *not destruction.*

What is decomposition? What is the agency which commences the operation and completes the process?

The popular meaning attached to the word is an erroneous one, or at best is very remote from that of the word *burning* or *combustion* as applied to the consumption of fuel in our dwellings and manufactories; yet decomposition and combustion are one and the same thing, varying only in degree, or rapidity, or both. It is the result of heat, without which nothing can live; nothing which, when dead, can again become food for the living; without which those arteries of the earth —the rivers, circulating the blood of the earth, would cease to flow. But for it everything containing moisture would be locked in the rigidity of ice; perfect cold being the normal condition of matter not subject to active heat.

This is well illustrated in the Arctic regions, where, owing to the equatorial fulness of the earth's form, the sun's rays are intercepted; and in proportion to such interception is the increase of cold, and a consequent decrease in the rapidity of decomposition or combustion of organic substances, so as almost to cease at times, as in the case of Arctic animals, which are occasionally found on thawing to be good food, though possibly they have been dead for many years. An artificial application of this law of nature is now in regular use in the Paris Morgue, or temporary receptacle of the unknown dead, by which means there is a valuable suspension of natural decay or dissociation of the substances of the body.

Where a perpetual state of ice does not exist, there decomposition fills up the intervals, the increase of the one being accompanied by the decrease of the other, until, as in the Tropics, decomposition reigns supreme, and there, as a consequence, life is more abundant.

Those elements no longer required by the dead are quickly set at liberty in gaseous form, ascending like aërial springs into the sea of the atmosphere, thence to be absorbed by animal and vegetable life, just as the ocean receives the polluted waters of rivers, only to purify and send them back, to run again in ceaseless circles, a never-ending journey.

Decomposition of the dead must surely be one of the most merciful of the Creator's provisions for the living. But for it, it would only be a question of time as to how long life could be sustained; for, supposing life to have commenced and continued its course by drawing upon a fixed and unrenewable quantity of matter, it would long since have shown signs of local, if not general exhaustion, resulting in a final extinction of living forms.

In all countries plants and animals have in vast numbers, and endless variety, become extinct, whilst of those still surviving many show indisputable signs of an extinction more or less remote.

Side by side with these, other forms have arisen in apparently undiminished numbers and variety, destined, like those which have gone before, to make room for others, which posterity must be left to study. However this may be, the human race does not yet excite a widespread interest on the score of extinction.

Man's extraordinary and unique power of adaptability to his environment, in nearly every climate which his insatiable curiosity leads him to explore, appears to ensure for him an endless succession of descendants, each possessing some modification of that which gave him birth, a constant modification being associated with the greatest vitality.

Go to the mountain stream, and, where it issues forth in all its sparkling freshness, ask it whence it cometh and whither it goeth? What will it say, and truly say, to the student of Nature? "I come from the avalanche; an iceberg I have been; I flooded the Ganges with its freight of dead and dying; I come from the swamp, and the ocean spray; I moistened the grape, bedewed the grass, rode here on the storm. I go to wait on life; to search out the haunts of man, whose pollution I will bear in my bosom to the sea of forgiveness, burying myself in its fulness, only to rise again pure and free to visit every clime!"

In like manner question the human body.

Listen, student of Nature; and, like the river, it says, "I know no rest. No rest is mine till the sun has ceased to work. I come from the inland grave, and the salt sea wave. In the countless forms in which I have borne a part, I have long since lost all trace of my origin. The form of man is not new to me. I have shared in all his glories, all his crimes. The Mastodon, and greater than he have used my substance, sharing it with all other forms of life, animal and vegetable. Fire is not new to me. Heat is at once my jailer and my liberator. When by its action I am freed from the bonds of one, I go to wait on other forms of life."

If, then, heat is the instrument ordained for the reproduction of living from dead forms, by natural or artificial combustion, advocates of the latter should doubtless be expected to prove its superiority to the former. It may be suggested that as Nature, when artificial aids are absent, is determined to burn the dead in her own silent mode of slow, so-called spontaneous combustion, why trouble ourselves about such work? Why not leave it to Nature? Certainly her patience is wonderful. She is still at work on the ancient mummies. The cunning of the embalmer only retards, it does not absolutely suspend disintegration. If our sense of smell did not inform us of the fact, the gradual loss of weight is clear proof.

Sanitary science, the pages of which book we are constantly cutting, is teaching us, lesson by lesson, that the production of diseases, of the Zymotic class at any rate, is as dependent upon seeds of "their kind" as is the husbandman for his harvest upon seeds previously buried. Following the simile a little further, we know that if grain be subjected to but a moderately high temperature, its germinating power is permanently destroyed.

We are but slowly realising or appreciating the fact that Nature has selected a code of laws which, with a glorious impartiality, are as much in favour of one form of life as another. We are learning that the world was not made for us alone, or indeed more for us than other forms of life. That struggle for existence which is so universal seems most severe for man. However that may be, Nature does not hesitate to use and sacrifice its noblest and loveliest forms, as hot-beds for the production of life, in forms so minute, and, so far as we can at present perceive, so utterly valueless and superfluous to Natural Economy, as to excite our bewilderment, and wound our self-esteem.

Self-preservation, the first law of nature, a constant incentive to animal and vegetable action, is exercised most by man. His superior intelligence best enables him to destroy or circumvent antagonistic forces. Slaying his fellow-men often calls forth his utmost energy and secures his most anxious consideration. He fosters the lives of many animals only to destroy them for food.

The advent of a little beetle from America has more than once sent a thrill of alarm through the country, involving considerable exercise of thought and means in order to secure its living absence. Whilst thus exercising our intelligence, we are fairly chargeable with being inconsistent to an extraordinary degree. The man who could be guilty of purposely introducing a plague of such insects would certainly deserve the worst possible fate; and yet in a perfectly legal, and publicly approved method we are perpetuating forms infinitely more destructive to human life.

Germatologists, if I may, so far as I know, coin a word whereby to distinguish the Tyndalls and Pasteurs of science, have clearly proved that those diseases which are classed as preventable are due to the presence in the body of the patient of organic forms of extraordinary minuteness, and in numbers beyond computation. The death of the patient is favourable to the further developement of such bacterial life. In some virulent cases of infectious and contagious diseases certain articles which have been used by the patient are burnt with a view to render them harmless. In those cases where the patients recover there is a lamentable want of efficient and sufficient isolation. Where death ensues matters are much worse. The body is in most cases treated as if it had lost its power to injure the living. Much unnecessary and purely conventional treatment ensues. I pass by the hideous proceedings conducted by the undertaker, as also the "correct thing" in black garments. Both are in a state of transition, the result of which may be left to the influence of universal education.

If in the country, the corpse will in most cases be carried to the highest point of the hamlet, where stands the village church. The building itself has in most cases been used as a receptacle for the deceased members of influential families. Over the tombs of these decomposing bodies the living assemble more or less frequently. Many of the vaults are during wet seasons partly filled with water. There is no mistaking the odours often perceived in such charnel houses. It is of course impossible to hazard a guess as to how many lives have been sacrificed as a result of such association with the dead on the part of the living. That they have been numerous cannot reasonably be doubted. Outside the building matters are worse. Here the rainfall has full play to percolate through and distribute the contents of the graves into the neighbouring wells, whence is drawn the drinking water for the living, who, in numberless cases, literally drink the dead in solution.

The normal increase of our population may be taken to be about a quarter of a million a year. With such a rapid increase of out resident population, the difficulty of obtaining water free from organic impurities is increasing to a serious extent, involving the outlay of vast sums of money. If, as we know it to be the case, water flowing from limestone ranges is, as a rule, highly charged with carbonate of lime, whilst that obtained from soils containing but small quantities of iron is found to be a solution of iron, how much more easily must the decomposing substance of the dead body be borne through the pores of the earth by the circulation of water? Just as surely as poison, when injected into the blood, is rapidly distributed through the whole system, so do the poisons of disease circulate in water round the dwellings of the living.

At the base of a hill within a few miles of this building flows a spring of ordinarily clear water, prized for drinking purposes. Some time ago a heap of farm yard manure was placed on high ground, a considerable distance from the spring. The hill is mainly composed of sand and sandstone. Shortly after the manure was so placed the water assumed the colour of pale tea, with an odour not to be mistaken, and obviously due to the manure heap.

In the case of suburban cemeteries the results are such as must ere long necessitate a radical change in the disposal of the dead. To economise area, graves are dug 15 to 20 feet deep. These are filled by piling the dead to within a few inches of the surface. Were an inquiry held, such as would be instituted by a Royal or a Parliamentary Commssion, into the internal economy of our public cemeteries, the result would probably startle the public into demanding an immediate change.

A local paper recently stated that—"Some terrible discoveries as to the causes of the rapid spread and lengthened stay of epidemic diseases in places where the principles of sanitary sepulture are imperfectly understood or not acted upon, have just been made by Dr. Freor, an eminent physician of Rio de Janeiro. That city is just recovering from the ravages of a very deadly visitation of yellow fever, and Dr. Freor, in his inquiries into the causes of the epidemic, came upon a dreadful fact that the soil of the cemeteries in which the victims of the outbreak were buried was positively alive with microbian organisms, exactly identical with those found in the vomitings and blood of those who had died in the hospitals of yellow fever. From a foot under the ground he gathered a sample of the earth overlying the remains of a person who had died of the fever and had been buried about a year before, and though it showed nothing remarkable at first appearance, he found to his horror when he placed it under the microscope, that it was thickly charged with these disease germs. Many of the organisms were making spontaneous movements; in effect, therefore, the cemeteries were so many nurseries of yellow fever. Every shower of rain washes the soil and the fever seed which is so thickly sown in it into the water-courses, and distributes the poisonous germs all over the town and neighbourhood. 'Each corpse,' says the doctor, 'is the bearer of millions of millions of organisms that are specifics of ill. Imagine what a cemetery must be in which the new foci are forming around each body.' How terribly fatal these germs are is proved by the fact that the blood of a patient injected into a rabbit killed the animal in less than an hour, and the rabbit's blood injected into a guinea-pig killed it in about the same time, and the guinea-pig's blood injected into another rabbit was also fatal, so that the chain of destruction is apparently endless."

Round these spaces devoted to the dead, the living accumulate, until only the greater area distinguishes them from the surcharged burial-grounds of town churches. By submitting the dead body to a much higher temperature than that which Nature finds sufficient for her purposes, it is rendered perfectly harmless to the living, presenting hygienic advantages which must make its adoption only a question of time.

Burning the dead formed a part of that wonderful civilisation of ancient Greece, to which we owe so much, and which will long hence be viewed with undiminished admiration. Excepting in the case of overheated haystacks and such artificial conditions, natural decomposition rarely occurs at a temperature high enough to destroy animal or vegetable life-germs. Hence the necessity for artificial treatment. There are so many methods by which the process could be successfully conducted that I will not enter on that branch of the subject. There would certainly be little difficulty in framing such regulations as should be a distinct improvement upon those which are at present in use for the disposal of the dead.

The only objection to Cremation which is really of such a character as to call for serious consideration, and to remove which, special precautions must undoubtedly be taken, is the fact that the operation would entirely destroy all trace of foul means as the cause of death. It occasionally happens that after burial circumstances arise which render it desirable to exhume bodies for purposes of examination. Although exhumation seldom results in anything very definite or valuable, public opinion is not likely to be in favour of abandoning it until it is satisfied that a good substitute is ready.

All regulations are more or less liable to abuse. People have been hung for offences they have had no part in. Society is occasionally shocked to find that an innocent person has undergone imprisonment or penal servitude (which by the bye are now synonymous terms), and endeavours to make such amends as are suggested by the circumstances. But it would not for a moment be contended that such unfortunate exceptions offer any inducement to abolish such punishments. It must also be admitted that under present conditions there are probably many persons buried whose deaths have been hastened by foul means, never suspected or questioned before or after burial, and with such precautions as are possible, I think it could be made much more difficult to dispose of such bodies than is now the case. Certainly it would not be difficult to improve upon the coroner's inquiry as at present conducted. One cannot repress astonishment that such a cumbersome and unqualified piece of administration has not succumbed to the want of confidence its decisions excite in the minds of those intimately acquainted with such courts. Since the public mind has ceased to be satisfied with verdicts attributing deaths to the "Act of God" it is manifestly unfair to expect juries, as at present constituted, to elucidate mysteries too deep for the coroner or themselves.

The legal profession never fails to supply the Judicial Bench with occupants who deservedly possess the fullest confidence of the public. Is it too much to say that the medical profession is equally well able to supply any required number of trained experts, in every sense qualified to give the public absolute facts respecting deaths calling for inquiry?

With such safeguards as medical men are well able to furnish, I will remind my hearers that the difficulty already referred to as presenting the most serious practical obstacle to cremation, does not apply to cases in which cremation is most necessary, *i.e.*, where deaths have arisen from diseases of an infectious nature, and which are those indeed which especially require to be dealt with in the manner proposed. Perhaps it will be desirable, at first at any rate, to limit cremation to such cases. Much would certainly be gained to the public health. The permanent extinction of any one of such diseases as are admitted to be preventable, would alone confer inestimable advantages on the human race.

Of course many will exclaim, "Oh! the idea of being burnt after death is horrible!" Is not a dead body a horrible mystery, and the disposal of it by any method a horrible duty?

Suppose for a moment that burial in the earth were a new custom, previous to which the dead were collected and deposited in the sea—which would have much to recommend it from a sanitary point of view—how horrified would many be at the proposal to dig a hole in the ground, in which to place their friends, with the knowledge that those first buried would in time be disturbed by the sexton's spade, and mixed up in inextricable confusion to make room for later comers. And though the proposal would be opposed to the teachings of true science, that would not be the cause of the opposition it would meet with, any more than the approval of cremation by science convinces those guided by sentiment rather than knowledge.

It is only a question of time. As the pages of the book of knowledge are unfolded, our stupendous ignorance is reduced, in spite of sentiment—sentiment which is unfortunately so rarely allied to truth.

Far be it from me, however, to despise sentiment. Life would indeed be dull without it. It may indeed be said that fact and fiction, truth and falsehood, are necessary to each other's existence. Truth shines brightest in a setting of fiction. But whilst disclaiming any inclination to repress sentiment or the healthy exercise of that imaginative power with which mankind is blessed, and by the aid of which so many of the burdens and toils of life are lessened, I make a clear distinction between it and prejudice, the child of ignorance and superstition, prolific parents, from whom it behoves us, to the best of our ability, to free ourselves and our children.

Civilisation is ever calling for and initiating measures intended to prolong human life. More, a nation's desire to extend the average life of its subjects is undoubtedly a measure of its civilisation, and is one of the first duties of statesmanship. The increasing density of our population is prompting us to adopt measures of a sanitary nature which have been too long delayed. The results so far, are such as ought to encourage us to the adoption of more general and consistent fulfilment of recognised sanitary principles. Hitherto legislation in sanitary, as in other matters, has been the result of a desire to cure rather than to prevent. Only when a nuisance has become so great as to be no longer bearable, are steps taken to alleviate if not remove it altogether.

Universal education will doubtless develop a more logical public opinion, which must insist upon a policy of prevention, as superior to cure, not only in matters of bodily health, but of crime also. It is solely as a preventive measure of a sanitary nature that burning the dead, in the opinion of so many, already calls for serious consideration; and in the hope that the subject will be received by this influential Society as one worthy of debate, I have ventured to bring it before you, that your thoughts may, as Matthew Arnold says, "play freely round it," untrammelled by prejudices unworthy of philosophers.