THE JOURNAL
OF THE
Quekett
MICROSCOPICAL CLUB

EDITED BY
A. W. SHEPPARD, F.Z.S., F.R.M.S.

SECOND SERIES.
VOLUME XI.

1910-1912.

London:
[Published for the Club]
WILLIAMS AND NORGATE,
14, Henrietta Street, Covent Garden, London,
and 7, Broad Street, Oxford.

PRINTED BY
HAZELL, WATSON AND VINEY, LD.,
LONDON AND AYLESBURY.

CONTENTS.

PART No. 66, APRIL 1910.

Papers.

Notes.

Proceedings, etc.

PART No. 67, NOVEMBER 1910.

Papers.

Notes.

PROCEEDINGS, ETC.

PART No. 68, APRIL 1911.

PAPERS.

NOTES.

PROCEEDINGS, ETC.

PART No. 69, NOVEMBER 1911.

PAPERS.

NOTES.

PROCEEDINGS.

PART No. 70, APRIL 1912.

PAPERS.

NOTES.

PROCEEDINGS, ETC.

PART No. 71, NOVEMBER 1912.

Papers.

Notes.

Proceedings, etc.

LIST OF ILLUSTRATIONS.

PLATES.

FIGURES IN THE TEXT.

THE JOURNAL
OF THE
Quekett Microscopical Club.

THE PRESIDENT'S ADDRESS.

SOME CONSIDERATIONS ON THE PHENOMENA OF PARASITISM AMONGST PROTOZOA.

By Prof. E. A. Minchin, M.A., F.Z.S.

(*Delivered February 22nd*, 1910.)

A living organism, whether plant or animal, which gains its livelihood at the expense of another organism is termed a parasite, and the organism at whose expense it lives is termed its host. The conception of parasitism, therefore, implies an antagonistic relationship between two correlated beings, parasite and host, each of which has, so to speak, its own point of view, the one attacking, the other defending. The phenomena of parasitism are of most wide-spread occurrence, and very varied in their nature. There is probably no species of non-parasitic organism which is not liable to the attacks of some parasite, and the same holds true even of a great number of parasites themselves, which are subject to be attacked in their turn by some other parasite.

The problems of parasitism are very complex, and are also very important, both from the more abstract point of view, as problems of natural history and bionomics, and also from the practical point of view, in their bearing upon questions of medical and veterinary science. In a brief space it is not possible to discuss all aspects and problems of parasitism, nor can such a discussion lay claim to any finality in the present state of our knowledge. I propose to lay before you a few facts of parasitism, restricting myself entirely to the field of the Protozoa, and to consider the phenomena solely from the point of view of natural history; a method of treatment which, though it cannot claim to solve all difficulties, may serve nevertheless to furnish certain guiding principles, and to throw some light, if only a side-light, on the questions at issue.

Amongst Protozoa, as is well known, many different modes of life occur. We are concerned here with those species which live constantly in association with some other organism of a distinct kind. Such a species may live either upon, or in, the organism with which it is associated; in the first case it is then termed *epizoic*, in the second *entozoic*. In all such cases of association, the species which are truly parasitic must be clearly distinguished from those which are not. Taking first the case of epizoic forms, it is found that in many cases they merely utilise the body of their host as a coign of vantage where they readily obtain their food, or as a convenient means of transport, especially when the epizoic form in question is of a sessile habit of life. Every naturalist is acquainted with the sea-anemones that live upon hermit-crabs, to the advantage probably of both animals, at all events to the detriment of neither. There are many similar cases amongst the Protozoa. As every microscopist knows, the appendages of many Crustacea, especially of Cladocera, such as *Daphnia*, and Copepoda, such as *Cyclops*, are often thickly beset with sessile Vorticellids or Acinetans, which obtain a convenient lodging but provide their own board. Other forms occur on the stems of Hydroids, as for example *Acineta papillifera* on *Cordylophora lacustris* (Hickling Broad, Norfolk). The common *Hydra* often bears a beautiful Infusorian which from its louse-like appearance has the name *Trichodina pediculus*, but which caters for itself and not at the expense of the *Hydra*. Amoebae are to be found creeping on the exterior of calcareous sponges, nourishing themselves on diatoms and other organisms. Similar instances could be multiplied indefinitely of epizoic species which are merely commensals, and not parasites in any sense of the word.

On the other hand, epizoic forms may be parasites, and even dangerous parasites, nourishing themselves at the expense of the animal they infest, and sometimes inflicting much damage upon it. It can easily be understood that an epizoic form which at first lived harmlessly upon some animal, drawing its supplies of food from the surrounding medium, might acquire the habit ultimately of obtaining its nourishment from the living substratum upon which it has planted itself. Examples of truly parasitic epizoic forms are the Flagellate *Costia necatrix* and the Infusorian *Ichthyophthirius*, both of which live on the skin of fishes and injure the epidermis.

In like manner, there are many entozoic Protozoa which inhabit the bodies, and more especially the intestines, of other animals, but which are not to be considered as true parasites; they simply feed on various substances to be found there, such as waste particles of food or faecal matter, or on other organisms, such as Bacteria—in short, on material which, from the point of view of the host, is superfluous or even noxious. Thus entozoic Protozoa may be quite harmless, perhaps even useful as scavengers to their host; but such forms may also readily acquire truly parasitic habits and become a danger to their hosts. A good example of this is seen in the amoebae found in the intestine of man. One species, *Amoeba coli*, which occurs commonly in man in all countries, is believed to be a harmless entozoic form. In the tropics, however, other species occur which find a more abundant source of nutrition in the living body which harbours them; they attack the epithelium and tissues of the intestine, devouring cells and blood-corpuscles and giving rise to a virulent form of dysentery; and they penetrate into the liver, where they destroy and corrode the tissues, producing most dangerous abscesses. It is often very difficult to draw the line between harmless and harmful entozoic Protozoa, but all such organisms must be considered suspect, and it is the safest course from the practical point of view to hold them guilty until they have been proved innocent.

The entozoic Protozoa which are truly parasitic are found inhabiting a variety of situations in the bodies of their hosts. In some cases the host is another species of Protozoon, into the body of which the intruder penetrates, living either in its cytoplasm or its nucleus. Amoebae are very subject to the attacks of intra-nuclear parasites, and the young stages of many Acinetans are parasitic upon other Infusoria. When the host is one of the Metazoa, the invading organism may be, in like manner, intra-cellular or intra-nuclear in habitat; or it may penetrate into the tissues, living amongst and between the constituent cells; or, finally, it may be found in one of the internal cavities of the body, such as the digestive tract, body-cavity, blood or lymph-spaces, urinary organs, etc., either living free in the cavity or attached to the lining epithelium. We may distinguish, in general, two ways in which these parasites may tax the resources of the host. Some of those living in the digestive tract may simply absorb the soluble products of digestion occurring there, thus diminishing the nutriment of the host by intercepting its food-supply. Other parasites, in the digestive tract or elsewhere, ravage the very substance of the body of the host, either by devouring cells and tissues, as in the case of the dysenteric amoebae already mentioned; or, and more usually, by absorbing the vital fluids and juices of the cells, tissues, or organs into which they penetrate, sapping in many cases the life-springs of the organism that harbours them.

As diverse as the modes of parasitism amongst Protozoa are the effects they produce upon their hosts. Some forms of these parasites cause no perceptible disturbance in the well-being of the host; even when they destroy cells and portions of the tissues, the damage may be slight, and is quickly made good without appreciable harm being done to the host. From this condition of more or less perfect harmlessness there is a continuous gradation in the ascending scale of capacity for harmfulness possessed by Protozoan parasites, culminating in species which bring about the death of their hosts with greater or less rapidity. Hence, parasitic Protozoa are commonly characterised as pathogenic, that is to say disease-producing, and non-pathogenic; these two terms imply, however, a distinction which is purely relative, since a "disease" may be anything from a slight and transitory indisposition to a severe and fatal illness. Hence, in discussing these parasites it is better to group them as lethal, or deadly, and non-lethal, including under the latter term both harmless parasites and those that produce ailments from which the host recovers more or less easily. The distinction between lethal and non-lethal parasites is not, however, in all cases absolute, since a parasite which is ordinarily harmless or but slightly harmful may exhibit lethal powers under certain conditions, especially when the host is in an enfeebled state of vitality from other causes. For instance, it is common to see animals living in captivity succumb to the effects of parasites which are harmless to them when living a natural healthy life in their wild state. The weakened powers of resistance of the host enable the parasite to flourish in an abnormal manner, and give it a capacity for harmfulness which it does not possess naturally. Hard and fast distinctions between different classes of parasites, from the point of view of the effects on their hosts, cannot always be drawn.

The great diversity in the effects of Protozoan parasites is very remarkable, and furnishes a most important subject for consideration and investigation. It would seem, at first sight, as if the presence of even a single parasite must cause some bad effect in the body of the host, even if the disturbance be so slight as to produce no appreciable symptoms of ill-health in the organism as a whole. If so, then the greater the number of parasites in the body of the host, or the larger the parasite itself, the greater should be the derangement in the health of the host. Consequently, the greater the powers of multiplication within the body of the host possessed by any given parasite, the more dangerous it might be expected to be. To a certain extent this expectation is realised. Thus the Gregarines of the suborder Eugregarinae, found commonly in the bodies of insects and other arthropods, are amongst the most harmless of parasites, so far as can be judged, and in these forms endogenous multiplication, as it is called, that is to say multiplication in the actively parasitic phase in the body of the host, does not take place. On the other hand, the parasites of the closely allied order Coccidia begin their cycle of development in the host by very active endogenous multiplication, overrunning some particular organ or tissue, and producing a sick and enfeebled condition which brings the host often to the verge of death, and sometimes even kills it. As a rule, however, animals attacked by coccidiosis, as the disease is termed, recover from the malady owing to the fact that when the host is brought very low, its condition appears to react on the parasite, with the result that the parasite ceases to multiply endogenously and enters upon a different reproductive phase; it produces resistant stages destined to infest new hosts, in the form of cysts and spores, which are inactive and do not absorb nutriment, but pass out of the body of the host. In consequence the diseased animal loses its parasites, or the greater number of them, and the tissues are left in peace to regenerate and repair their injuries, provided they have not gone beyond the point at which recuperation is possible.

If the action and reaction of host and parasite were relations dependent simply on the number or bulk of parasites present in the body of a given host, the problems of parasitism would be comparatively simple. Examples can be brought forward to show that in many cases the effects produced by Protozoan parasites cannot be explained, either by the number of parasites present or by the aggregate bulk of the parasites in proportion to that of the body of the host. The effect produced by a given species of parasite on a given species of host is a specific reaction, which differs markedly when one of the two factors is varied. It is not uncommon to find insects with their digestive tract or body cavity crammed with parasitic gregarines, of relatively large size, but causing no apparent inconvenience to the host. On the other hand large mammals may be killed by minute organisms in scanty numbers. A better comparison is furnished by considering closely allied parasites and hosts respectively. A rat may have its blood swarming with *Trypanosoma lewisi*, without being apparently any the worse for it. On the other hand, in a man dying of sleeping sickness, caused by *T. gambiense*, or in a ruminant dying of nagana (tsetse-fly disease), caused by *T. brucii*, the trypanosomes may be so scanty as to be exceedingly difficult to detect.* These facts strongly suggest, as has been pointed out by medical authorities, that the parasites produce a specific toxin. Only in a single case, however, has it been claimed that a toxin has been isolated from a Protozoan parasite, namely the "sarcocystine" produced by the parasites of the genus *Sarcocystis* (Sarcosporidia).† The subject is one which remains to be investigated, and in the present state of knowledge it would be unprofitable to discuss it further here.

The interaction of host and parasite is a question of great practical importance, which in consequence has been studied chiefly from the medical standpoint, that is to say, from the point of view of the host. I propose here, as I have already said, to deal with the question as a naturalist, and to discuss the problem rather from the point of view of the parasite; and with this object I shall begin by a brief consideration of the facts of parasitism in general.

A parasite is, like any other living being, an organism struggling for existence in a hard and cruel world. The difficulties, however, against which a parasite has to contend, in the struggle for existence, are different in many respects from those which beset a free-living organism. When once a parasite has obtained a footing in its proper host, the question of food-supply is solved for it, since it finds itself lodged in the midst of abundant nutrition so long as its host lives. On the other hand, if the species is to be maintained, it is essential that the offspring of the parasite should be able to infect new hosts—a matter usually of great difficulty, and one in which the chances are all against the parasite in most cases. To ensure dissemination of the species a large number of offspring must be produced, and special adaptations and mechanisms may be necessary. Hence in parasites, the more they become specialised and adapted to parasitic life, the more the organs and functions of nutrition tend to become simplified, and the greater the tendency to elaboration of the reproductive system. It is especially amongst parasites

---

* Compare Laveran and Mesnil, "Trypanosomes and Trypanosomiases," translated by Nabarro (Baillière, Tindal & Cox, 1907), pp. 146–150.

† *Comptes Rendus Soc. Biol. Paris* LI. (1899), pp. 311–14.

that we find the greatest complication in the structure and mechanisms of the generative organs, the most extraordinary and delicately-adjusted adaptations of the propagative phases, and the most astonishing fertility.

So long as the parasite has not made the necessary provision for propagating its kind and disseminating its progeny, it is against its best interests to kill or greatly weaken its host. The interests of the two are bound up together, and the death of the host, before the parasite has completed its reproductive arrangements, necessarily entails the extinction of the parasite. The ideal host, from the point of view of the parasite, is one that is "tolerant," that is to say, one that can support the presence of the parasite and keep it supplied with the nutriment it requires, like a good mother or nurse, without suffering in health and vigour to any marked extent. When once, however, the parasite has matured and produced its reproductive phases, the life or death of the host may be a matter of indifference to it. In some cases the death of the host may even be necessary for the dissemination of the parasite.

From these general considerations it is seen that reproduction, and above all the dissemination of the progeny in a manner adapted to the special circumstances of its mode of life, are by far the most important functions of a parasite. Turning now to the special consideration of Protozoan parasites, we find that diverse conditions of their mode of life and habitat impose a corresponding diversity in their reproductive phases and their modes of dissemination.

The passage of a parasite from one host to another includes two manœuvres, so to speak: the passing out from the first host, and the passing into the second. Primitively it may be supposed that this migration was effected simply by the unaided efforts of the parasite itself, that is to say, that the active motile parasite would force its way out of one host, move freely in the surrounding medium, and sooner or later attack and penetrate a second host. This primitive method of transference doubtless occurs in many cases, especially amongst epizoic forms. In the case of entozoic forms its occurrence is more doubtful. It is very probable, however, that the spirochaetes found infesting certain bivalve molluscs, such as *Spirochaeta balbianii* of the oyster, and *S. anodontae* of the pond-mussel, swim out of one mollusc and into another. Active migration of this kind, however, is very rare amongst entozoic parasites, if it occurs at all. In the first place the conditions of life within a living body, in the midst of organic fluids, are so different from those in the open water, whether salt or fresh, that it is hardly to be expected that a delicate unicellular organism adapted to the one mode of life could stand the sudden change to the other. In the second place, it is clear that active migration of parasitic Protozoa could only be effected when the host is an aquatic animal, and not when it is a terrestrial organism. The only instances of active migration of entozoic parasites known with certainty are those in which the parasite can penetrate a mucous membrane, and is thus able to pass from one host to another when two such surfaces are in contact. In this way the trypanosome of dourine in horses (*T. equiperdum*) passes from one host to another during coitus, and the transmission of the parasite of syphilis is another instance.

Speaking generally, and excluding for the moment those cases in which the transmission is brought about by means of an intermediary host, the propagative phases of Protozoan parasites take the form of inactive, resting stages in which the body of the parasite is protected against adverse external conditions by a tough protective membrane. In the form of resistant cysts or spores the parasites in a dormant state brave the rigours of the external world, and are able to withstand the heat and drought of summer, the cold and frost of winter. Like seeds they offer an inert resistance to the elements and are disseminated passively, and like seeds they germinate when they reach a suitable soil, but not till then.

Let us consider now the manner in which the first step in the propagation is effected, that is to say, how the propagative phases leave the body of the host.

Many, perhaps the majority of Protozoan parasites occupy positions in the body of the host whence the propagative phases can pass without difficulty to the exterior. This is the case when the parasite is lodged in organs which have ducts or passages opening directly or indirectly to the exterior: for instance, in the digestive tract and its dependences, such as the liver, salivary glands, malpighian tubules of insects, etc.; or the urinary organs and ducts. In all such cases the propagative phases of the parasite pass harmlessly to the exterior. The host may in this manner get rid entirely of its parasites, without however necessarily acquiring immunity to fresh infections; or, on the other hand, the parasite may keep up its numbers in the host by "endogenous" multiplication while at the same time it is continually sending forth the propagative phases destined to infect new hosts. In the majority of Protozoan parasites the relations to the host are of this type, and the parasites are neither lethal nor pathogenic to any great extent.

On the other hand, there are many instances in which Protozoan parasites occupy a position in the body of the host whence escape by anatomical channels is not possible, or if possible, not suitable. This is the case when the parasite inhabits some enclosed space in the body, such as the coelome or general body-cavity, or the blood-system; or when it attacks deeply-seated cells or tissues of the body. In such cases there are at least six known methods whereby the parasite is disseminated or transferred to fresh hosts.

1. The resistant stages of the parasite may be set free by the death and decay of its host. This appears to be the manner in which some of the tissue-infecting parasites of the order Myxosporidia, especially the family *Myxobolidae*, are disseminated. These organisms are for the most part parasites of fishes, and are often very deadly in their effects.

2. The parasite may cause tumours and ulcers, which suppurate and so set free the spores or cysts of the parasite. This again is an effect commonly produced by tissue-parasites such as the *Myxobolidae*. In such cases the parasite is always pathogenic and frequently lethal to the host.

3. The parasite remains in the host until the latter is eaten by some animal which preys upon it. The propagative phases of the parasite are able, however, to resist digestion by the

animal that has devoured their former host, and pass unaltered through its intestine, to be finally cast out with the dejecta. This is almost certainly the method by which the common *Monocystis* of the earthworm infects its host. The parasite produces resistant spores in the worm; the worm is eaten by a bird, mole, frog, or some other animal, through the digestive tract of which the spores of the *Monocystis* pass unaltered; they are scattered abroad with the faeces, and may then be swallowed by another earthworm, in which they germinate and produce an infection.

4. As in the last case, the host, together with its parasites, is devoured by some animal, in which, however, the parasite is not merely carried passively, but becomes again actively parasitic. Hence in this case there is an alternation of hosts, one of the two hosts becoming infected by devouring the other. This mode of infection, which is well known to be of frequent occurrence amongst certain parasitic worms, such as Cestodes (tapeworms), is probably also frequent amongst Protozoa; but at present only one case of it is known with certainty, that of the species of the genus *Aggregata*, parasites of crabs and of Cephalopods, such as the cuttle fish and the octopus. In the Cephalopod the parasite forms resistant spores which pass out with the faeces and may then be devoured by crabs: in the crab the spores germinate and give rise to a second form of the parasite which lives and multiplies in its new host. If, as frequently happens, the crab is devoured by a cephalopod, the parasite completes its life-cycle by becoming once more a parasite of the cephalopod.

5. The Protozoa parasitic in the blood of vertebrates are disseminated in all cases, apparently, by bloodsucking invertebrates, such as leeches, ticks, or insects, which take up the parasites by sucking the blood of an infected animal. Later on the parasite may be inoculated into a second vertebrate host by the blood-sucking invertebrate when it sucks blood at a later feed. In some cases the transference of the blood-parasite from one vertebrate host to another may be effected in a purely mechanical manner by the invertebrate, but in most cases the invertebrate is a true host in which the parasite multiplies and goes through a cycle of development. Hence in such cases also there is an

alternation of hosts and a complicated life-cycle, which has been most completely studied in the case of the malarial parasites of man, transmitted by the agency of mosquitoes.

6. In some cases the parasite may penetrate the ovary of its host, pass into the ova, and thus infect the embryo and the next generation of the host. Transmission of this kind is known in a certain number of cases: for instance, in the "pébrine" disease of silkworms caused by *Nosema bombycis.* It is never the sole method of transmission, but is always supplementary to other methods.

To turn now to the methods by which Protozoan parasites penetrate into new hosts. We find four known methods, which can be summarised very briefly after what has been stated already. The commonest is the method of casual or contaminative infection, where the host infects itself by taking up the propagative phases of the parasite accidentally from its surroundings. Most usually infection takes place by way of the mouth, with the food; but it may be effected by the respiratory organs. Other modes of infection are the contagious, as in dourine already mentioned; the inoculative, as in malaria and other diseases caused by blood-parasites; and the so-called hereditary method, as in *Nosema bombycis* and other cases.

From the foregoing summary of the methods by which Protozoan parasites are propagated and spread from one host to another, it is clearly seen that there are only very few cases in which it is of direct advantage to the parasite to cause the death of the host, and even then only when the propagative phases of the parasite are fully matured. In cases where the parasite is disseminated by its host being devoured by another animal, it is necessary for the propagation of the parasite that the host should die a violent death, but not through the agency of the parasite; on the contrary, the interests of the parasite are best served by the host remaining in good health until the fatal moment arrives, unless it be supposed that some weakening of the host renders it more liable to become the prey of its enemies. Blood-parasites, transmitted by the inoculative method, are not perceptibly benefited by the host's illness, and certainly not by its death. It is, however, very necessary for this method of dissemination that the required phases of the parasite should be sufficiently abundant in the blood to make sure of infecting the invertebrate that sucks the blood and transmits the parasite. To ensure this taking place it is essential that the parasite should multiply and swarm in the blood to an extent that may, in many cases, lead to pathogenic and even fatal results. Hence one interest of the parasite may, so to speak, clash with another, and the all-important object of dissemination cannot be attained without bringing about a state of affairs which puts an end to the host and to the parasite with it; a result which, though detrimental to the parasite, may not be seriously so, if the death of its host do not supervene until there has been time for the dissemination of the parasite to have taken place. No reasonable person, however, could expect any adaptation to be absolutely perfect.

The inevitable conclusion from a general consideration of the facts of parasitism amongst Protozoa is, therefore, that it is hardly ever to the advantage of the parasite to be pathogenic, and still less so to be lethal to its host. This conclusion is borne out by the facts, for when the known forms of Protozoan parasites are reviewed and considered in their entirety, it is found that the vast majority of them are quite harmless to their hosts. Pathogenic and lethal parasites are the exception amongst the Protozoa, and are greatly in the minority when compared with the harmless forms. The attention of investigators has been so much focussed on the disease-producing forms, on account of their practical importance, that they appear at first to overshadow the harmless forms which obtrude themselves less on the public attention, though far more numerous. Thus, if trypanosomes are mentioned, most people think at once of the deadly parasites of sleeping sickness or other diseases; and it comes almost as a shock to find that the fishes and frogs of our waters, and the wild birds and animals of this and other countries, are commonly infested with trypanosomes without being perceptibly the worse for these parasites. In fact, the disease-producing Protozoa are to be considered as exceptional and aberrant forms; the effects they produce on their hosts are detrimental to their own interests, and they are instances of what has been termed by Metchnikoff a "disharmony" in nature. How is the existence of these lethal forms to be explained, and what is their significance? The best manner for a naturalist to attack this problem is to consider groups in which both harmful and harmless forms occur and are represented by closely allied species. Good instances of such cases are presented by the trypanosomes of mammals, of which two groups may be briefly described and discussed.

In rodents we find a group of trypanosomes of which *Trypanosoma lewisi* may be taken as a type, and I shall therefore refer to them for short as the *lewisi*-group. *Trypanosoma lewisi* flourishes in the two common species of rats (*Mus decumanus* and *M. rattus*), but not in any other animal, not even in the mouse, which has its own peculiar species of trypanosome (*T. duttoni*). Similarly *T. cuniculi* is specific to the rabbit, and *T. rabinowitschi* to the hamster. All these four trypanosomes of rodents are, however, very similar in their appearance and morphological characters, and can scarcely be distinguished except by the physiological action and reaction between them and their hosts; there can be no doubt that they are closely allied species, differing only in that each is adapted constitutionally to parasitism upon a special host. These specific trypanosomes of rodents of the *lewisi*-group are further quite harmless, under ordinary circumstances, to their hosts. When a rat becomes infected with *T. lewisi*, the trypanosomes at first multiply rapidly and swarm in the blood; then all multiplication ceases and the parasites gradually die out, after which the rat is immune to the parasite, and cannot be infected with it a second time.

Constrasting with the *lewisi*-group is another which we may term the *brucii*-group, the members of which are remarkable for their deadly powers, each species being the cause of some fatal disease. Such are *T. brucii*, the cause of nagana, or tsetse-fly disease in horses, cattle and dogs; *T. gambiense*, the cause of sleeping sickness in man; *T. evansi*, the cause of surra in horses; *T. equiperdum*, the cause of dourine in horses; and several other species. In this group also the parasites are practically indistinguishable from one another by appearance or structure; the species can only be identified by their reactions, but this is much more difficult in the *brucii*-group, since, unlike the *lewisi*-group, the species are not limited to one particular type of host. Every member of the *brucii*-group can flourish in a great many different hosts, though there are limits even to their powers of adaptability. Thus *T. brucii* can flourish in ruminants, dogs, rats, and many other mammals, but apparently not in man. *T. gambiense* can infect man, monkeys, dogs, rats, etc., but not ruminants. When a rat is infected by *T. brucii*, the infection runs a course quite different from that of *T. lewisi*. The parasites in the former case multiply indefinitely until the blood contains more trypanosomes than blood-corpuscles, and the multiplication of the parasite is only ended by the death of the host and with it of the parasites.

Comparing and contrasting these two groups of trypanosomes, it is impossible to avoid in the first place the conviction that in each group the species are closely allied, and descended from a common ancestor. The ancestor of the *lewisi*-group had certain structural characters distinguishing it from that of the *brucii*-group, but each of these two ancestral species has given rise to a number of species which are practically indistinguishable by structural characters, and can only be differentiated by their physiological reactions. We have here a beautiful instance of species in the act of arising, and caught, so to speak, at a stage in which divergent physiological adaptation has not yet brought about structural differentiation. It is seen further that the species of the *lewisi*-group are quite specific in their reactions, and are each limited to certain definite hosts, while those of the *brucii*-group are far less specific, and are limited only to a comparatively wide range of hosts. We may reasonably regard the *lewisi*-group as the further advanced in the evolution of specific characters, and the *brucii*-group as being in a more incipient stage of specific differentiation. Finally, it is to be noted that the *lewisi*-group are typical harmless parasites, while the *brucii*-group are characteristically of the lethal type.

Further light is thrown on this question by a very interesting discovery made by Bruce with regard to *T. brucii*. He found that in districts where tsetse-fly disease was rife, *T. brucii* was to be found as a natural parasite of wild game, to which it is apparently as harmless as *T. lewisi* to rats. By the agency of tsetse-flies, *T. brucii* is taken up from its natural hosts, and inoculated into domesticated animals of various kinds, in which it flourishes, and to which it is extremely fatal. To the native races of domestic animals it is less deadly, but imported animals, new to the country, succumb rapidly. Thus the wild game acts as a "reservoir," from which the infection of *T. brucii* spreads to other animals.

From these facts it is seen that *T. brucii* is most harmless to those hosts in which it is a "natural" parasite, that is to say, in which there is what may be termed a racial adaptation of the host to the parasites, and which are constitutionally able to withstand the disease-producing powers of the parasite. On the other hand, it is most deadly to those races in which it is a new parasite, and which possess no constitutional power of defence. The state of affairs is perfectly comparable to that seen in such a disease as measles, which is a comparatively harmless disease in Europeans, but an extremely deadly disease amongst races in which it is freshly introduced. What is the precise nature of the mechanism of attack and defence is the fundamental problem of the researches on immunity which are now being conducted with such ardour and industry by pathologists all over the world, and which cannot be discussed now. The facts of parasitism indicate clearly, however, that when a race of hosts has been long associated with a race of parasites, the hosts gradually acquire constitutional powers of resistance to the parasite, which the hosts do not possess when first brought into relations with the parasite. Hence it may be said that a new parasite will generally be a dangerous one, though it does not necessarily follow that the converse is true, and that a dangerous parasite is always a new one.

Here it must be pointed out that there are two ways in which a given species of parasite is "new" to a species of host. On general grounds we must suppose that a parasitic organism of any kind is descended from ancestors which were not parasitic. Hence there must have been a period in the evolution of any parasite when its ancestors were first adapting themselves to parasitic life and establishing themselves in the body of their host, overcoming all resistance to their invasion. This kind of newness was probably not accompanied with lethal powers on the part of the parasite, since the capacity for reciprocal attack and defence on the part of the two organisms concerned was probably developed gradually in each organism and would tend to balance each other. The newness which is dangerous is seen where an organism with fully developed powers of parasitism in one "tolerant" host acquires the capacity for living in another host not adapted to it. This consideration throws perhaps some light on the disease-producing powers of trypanosomes in general. From the known facts of the development of trypanosomes, it seems highly probable that they have in all cases two hosts, a vertebrate and an invertebrate. There are further many considerations which indicate that they were originally parasites of the digestive tract of the invertebrate host, and that when the latter took to blood-sucking habits, the trypanosomes became accustomed to nourishing themselves on blood, and were finally able to establish themselves in the vertebrate host. This view may explain why these flagellates are always perfectly harmless to the invertebrates, their "old" hosts, and only pathogenic to vertebrates, their "new" hosts.

Returning now to the consideration of the examples specially selected, it is seen that the harmlessness of the *lewisi*-group is due to the fact that the species are specifically adapted to certain hosts and cannot maintain themselves in any other but those particular hosts. On the other hand, the lethal powers of the *brucii*-group are associated with the fact that its members, even when specifically adapted to a "natural" host, can nevertheless establish themselves also in a wide range of "new" hosts, with fatal results to the latter. If I am right in regarding the *lewisi*-group as further advanced in specific differentiation than the *brucii*-group, it then becomes probable that the natural tendency of evolution is to bring about a balance in the profit and loss account of parasite and host, and that the species of pathogenic trypanosomes of the *brucii*-group would tend in the future to become harmless parasites of certain hosts. This evolution, however, would be a long and gradual one, perhaps attained only by a painful process of natural selection of the hosts.

On the other hand, if I am right in regarding the members of the *brucii*-group as newly-arisen species descended from a common ancestral species of trypanosome, it follows that the ancestor must, through some process of variation, have developed the power of establishing itself in new hosts and invading, so to speak, fresh pastures. It may be supposed, therefore, that if this has happened once it may happen again, and that a parasite which is now specific to a single tolerant host may, by some unexplained process of variation, acquire at any time the power of infecting other hosts and so giving rise to new species of parasites ultimately. The facts of variation are at once the most patent and obvious characteristic of living beings, and the most difficult to trace to their causes; their study is of the utmost importance for understanding the evolution and the origin of species, and the phenomena of parasitism offer a field for the study of variation of a peculiar kind, that is to say, variation in physiological and constitutional rather than morphological characters. The variations in the powers of parasitic organisms are clearly of the greatest practical as well as theoretical importance, when it is seen that the spread of a parasite into new hosts is likely to be accompanied with the most deadly results to the hosts invaded by it. In fact, the origin of species amongst parasites is bound up with the question of the origin of disease. Ray Lankester has suggested* that the extinction of animals seen in past geological periods may have been in many cases due to their extirpation by some species of parasite new to them.

Thus it is seen that in the origin of species amongst parasites there are, as in other organisms, two steps: first the appearance of variations, with the resultant disharmony seen in the lethal forms; secondly, by a gradual process of reciprocal adaptation between host and parasite, the establishment of more normal harmonic relations, associated with definite specific characteristics and reactions on the part of the parasite and host.

* *Quarterly Review*, No. 399 (July, 1904), p. 134.

NOTE ON OUR PRESENT KNOWLEDGE OF THE CHOANOFLAGELLATA.

By J. S. Dunkerly, B.Sc.

(*Read November 23rd*, 1909.)

The Choanoflagellates are a group of the Protozoa which have been rather neglected by microscopists. This neglect is due to more than one cause. They are very minute organisms, requiring high powers for their study; they are not parasitic; and they are not usually motile. Some one or all of these causes may account for the fact that although these Choanoflagellates were discovered over forty years ago, yet few microscopical workers are familiar with them.

They were first recorded accurately by James Clark, of America, in 1867, although previous workers may have seen them; *Epistylis botrytis* of Ehrenberg probably being identical with what is now known as *Codonosiga botrytis*. Stein, in his wonderful monograph on the Infusoria, says that, although he had worked many years at Infusoria, he had never seen a collared flagellate until after reading J. Clark's account of them. He then remembered having previously seen the empty cases or loricae of *Salpingoeca*, and before a year had passed he found many specimens of Choanoflagellates, including one or two new species. We all know in microscopy how much easier it is to find anything when we know that it is there to be found; unfortunately this in some cases leads to wilful interpretation in accordance with preconceived notions. Although Stein had investigated the Choanoflagellata as early as 1867, he did not publish the greater part of his figures until 1874. To Saville Kent belongs the credit of publishing the first systematic account of the group. He was interested in J. Clark's description of them, and at once started to look for Choanoflagellates. In his *Manual of the Infusoria* (1880–82) he gives an account of several new genera and many new species. Some of the latter are exceedingly doubtful, as he gives different specific names to forms which, from his own figures, appear to be identical. However, he seems to have seen more of, and certainly more in, the Choanoflagellata than any other observer. He had the good fortune to be able to use some very high-power objectives of Powell and Lealand, including a $\frac{1}{50}''$. Many of his specimens came from aquaria, either marine or fresh-water, at Brighton, Hastings and even the Crystal Palace. Bütschli, in his *Protozoa* (1883–87), added little to Saville Kent's account of the group.

The next investigator to devote special attention to the group was R. Francé, of Hungary. He published in 1897 a monograph of the Choanoflagellata, or Craspedomonadina, as he styled them, with a valuable historical and critical account of the group. He wisely revised Saville Kent's specific nomenclature, recognising that the different varieties must be classed under general forms or types rather than as separate species.

Fisch, a professor of botany, described division and the formation of swarm-spores, in *Codonosiga botrytis*, in a very interesting paper published in 1885. A few isolated papers have contained descriptions of new species, but our knowledge of the structure and affinities of these collared monads is still very incomplete.

A typical Choanoflagellate is seen in Pl. I., Fig. 1. It has an oval, naked protoplasmic body with a nucleus, one or two contractile vacuoles, and a single flagellum arising from a basal granule or blepharoplast, which stains deeply in prepared specimens. Surrounding the base of the flagellum is the characteristic collar, a protoplasmic membrane, cylindrical or basin-shaped. The whole body is motionless, except when shaken by the violent movements of the flagellum, the latter being in constant movement either along its whole length or especially at the tip.

Sometimes an apparent desire for exercise, especially after division, leads the animal to leave its station and swim about in the water. It is interesting that the method of progression is then with the flagellum hindmost, whereas in most free-swimming flagellates the flagellum is foremost. The collar is contractile, and at certain times retractile. The nucleus lies in the body near the base of the flagellum, and is generally visible as a rather dense sphere surrounded by a clear area. One or two contractile vacuoles are present at the end of the body furthest from the flagellum, and may be seen to pulsate more or less regularly. Several food vacuoles containing solid particles render evident by their movements a circulation or streaming of the body protoplasm.

The method of nutrition is undoubtedly by the ingestion of solid particles, bacteria, etc., but where and how these particles are taken into the body are disputed points. Saville Kent described them as passing up the outside and down the inside of the collar, to be absorbed by the body protoplasm near the base of the flagellum. He stated that the movement was brought about by a circulation in the hyaline protoplasm of the collar, which he was able to observe by the use of exceptionally high-power objectives. No one of the other workers on these forms has seen this circulation, and to any one who has observed the collar through a $\frac{1}{12}''$ objective, Saville Kent's description sounds wonderful indeed. Even with the best illumination and using eyepieces × 12 or × 18, the collar can rarely be seen as other than two lines, one on either side of the flagellum. For this reason, Bütschli and Fisch both depict the collar thus, although recognising that it is really a collar-like membrane. Vacuoles can be seen protruding from the general outline of the body at the base of the collar; according to both Bütschli and Fisch the food particles are absorbed into the body outside the collar, according to Saville Kent inside the collar. Entz and Francé hold a middle course, and describe the collar as a spirally wound membrane down which the food passes into a specialised area of the body which functions as a mouth. There is no direct evidence to prove the existence of this spiral arrangement of the collar, and at present the suggestion remains a rather doubtful explanation of the facts.

The normal method of reproduction of the Choanoflagellata is fissiparous, and, as usual in the Flagellata, by longitudinal division. The nuclear phenomena during division have been described in *Codonosiga botrytis* by Fisch, and seem to resemble that modified karyokinesis which is exhibited by Euglena. The process of encystation is probably common, and it is stated that the cysts may give rise to numerous small flagellate spores (swarm-spores), which develop directly into the adult form. Up to the present conjugation has not been observed in this group of Infusoria.

The habitat of Choanoflagellates is restricted by the fact that normally they are all sessile forms. They can be found growing on green filamentous Algae, such as *Vaucheria*; on chain diatoms; on other Infusoria, *e.g. Vorticella*; and on Rotifers, etc. As regards their distribution, they are probably cosmopolitan, and will be found in fresh or sea-water wherever looked for. They have been recorded from most European countries, North and South America and India.

With regard to the forms and classification of these beautiful organisms, mention need only be made of the chief distinctive forms met with. The type described above is *Monosiga* (Plate I., Fig. 1). A similar form, but stalked, is *Codonosiga* (Plate I., Fig. 2). *Codonocladium* resembles *Codonosiga*, but the colony has secondary branches forming umbels. *Proterospongia* is an interesting colonial Choanoflagellate with several *Monosiga*-like individuals embedded in a very transparent ground mass. This form led Saville Kent to believe that sponges were but colonies of Protozoa related to Choanoflagellates. There is certainly a remarkable similarity between a typical Choanoflagellate and the choanocytes of sponges, but our knowledge of the development of sponges, largely due to the work of Professor Minchin, shows that the relationship between Choanoflagellata and Porifera, if any, must be very remote. *Diplosiga* is a form found by Frenzel, possessing two collars. All the above-mentioned forms are without any protective covering, but the following forms secrete a case or lorica in which the animal lives.

Salpingoeca (Plate I., Figs. 3 and 4) is the genus most rich in species, about thirty-two having been described. Probably, however, some of these are varieties or growth forms; and Francé, in his monograph, contents himself with describing five *types* of *Salpingoeca*. *Polyoeca* (Plate I., Fig. 5) is a colonial *Salpingoeca* seen by Saville Kent in 1874, but appears to be of rare occurrence, for neither Francé nor the other workers in this group seem to have seen it. The author was fortunate enough, however, to find a new species of this genus fairly plentiful in a tank at the Plymouth Biological Station. *Diplosigopsis* is a form found by Francé, with two collars and a lorica, corresponding to the non-loricate form *Diplosiga*. These double-collared forms are puzzling, and from Francé's drawings of *Diplosigopsis* one is tempted to suggest that the second collar may be really the neck of the lorica in a *Salpingoeca*. If such forms do exist, however, they should not be classed with single-collared forms as Francé classes them, and certainly, too, they would rather tend to weaken Entz's theory of the spiral structure of the collar, unless the animal were the happy possessor of two mouths.

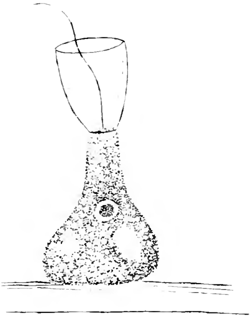
The affinities of the Choanoflagellata are quite obscure. Francé thought that *Bicosoeca*, a flagellate living in a lorica, and with a peculiar membrane at the base of the flagellum, might be related to *Salpingoeca*; but in many respects *Bicosoeca* appears to be rather specialised. In *Phalansterium* we find a membrane encircling the base of the flagellum, resembling, but not identical with, the collar of Choanoflagellates. But *Phalansterium* does not point to any particular relationships, being itself a peculiar type.

To the earnest microscopist desirous of investigating structures difficult of interpretation the author can heartily recommend this group for research.

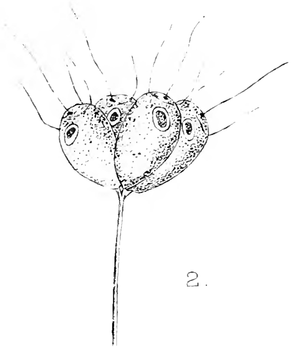
EXPLANATION OF PLATE I.

Fig. 1. *Monosiga ovata*, × 1500.
,, 2. *Codonosiga botrytis*, stained carmalum, showing blepharoplast at base of flagellum, × 1000.
,, 3. *Salpingoeca napiformis*, Francé, from Plymouth, × 1200.
,, 4. *Salpingoeca ampulla*, S. Kent, from Plymouth, × 1200.
,, 5. *Polyoeca dumosa*, from Plymouth, × 1200 [from *Ann. and Mag. Nat. Hist.*, Ser. 8, Vol. V., February 1910].

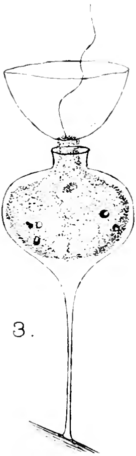
Figs. 1, 3, 4 and 5 are drawn from living specimens.



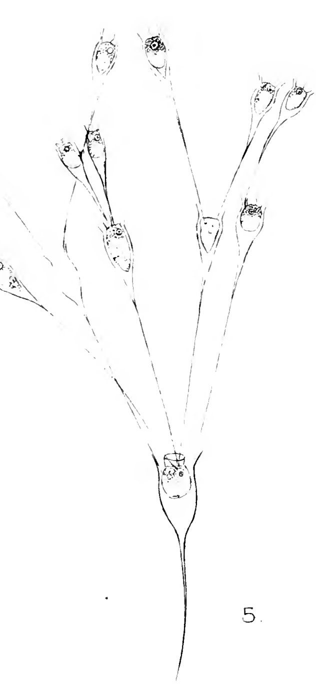
1.



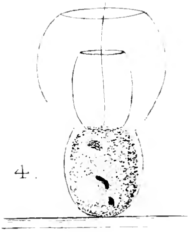
2.



3.



5.



4.

J. S. D. del. A. H. Searle lith.

Choanoflagellata.

NOTICES OF BOOKS.

Annali della Regia Scuola Superiore di Agricoltura di Portici, series 2, vol. vii. (1907); vol. viii. (1908).

We have received the above *Annali* from the Director of the School of Agriculture, Portici (Naples), giving the results of the work carried out during the years 1907 and 1908. Several of the papers are of biological interest, and will repay attention by those members who have devoted themselves to Entomology. Of such papers is the contribution by Signor G. Martelli, on the biology of *Pieris brassicae*, L., in which he deals with the life-history of the insect in the neighbourhood of Portici, and with the various parasites belonging to the Chalcididae, Tachinidae, etc., which infest it during its larval stage. Dr. Luigi Masi describes the Italian Chalcididae in two elaborate papers (vol. vii. and vol. viii.), which form a very valuable contribution to our knowledge of this extremely difficult division of the Hymenoptera. Each species is dealt with in detail, and the perfect insect figured in the text. Following Dr. Masi's paper is Dr. G. Leonardi's monograph on the Italian Coccidae.

Signor F. Silvestri has made a study of the embryology of the following parasitic Hymenoptera: *Ageniaspis fuscicollis*, Dalm., *Encyrtus aphidivorus*, Mayr., and *Oophthora semblidis*, Aur. He illustrates his paper on this subject with figures showing the segmentation phenomena in parthenogenetic ova, the formation of the blastoderm, and the development of the various organs in the embryo.

The results of a series of experiments on the micro-biology of the maceration (steeping) of vegetable fibres for industrial purposes is contributed by the Director, Prof. G. Rossi, and his assistants. The textile fibres used for the experiments were hemp, flax, ramié, gelso (the fibre of *Morus alba et nigra*), and New Zealand flax. The method adopted was to inoculate the steeping-vat with a pure culture of one or other of the pectose-dissolving bacteria, such as *Granulobacter pectinovorum, Plectridium pectinovorum*, *Bacillus macerans*, *B. pecticus*, or *B. Kramerii.* The bast fibre, separated by this process of selective fermentation, was then subjected to microscopic analysis.

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the meeting of the Club held on October 26th, 1909, Prof. E. A. Minchin, M.A., F.Z.S., President, in the Chair, the minutes of the meeting held on June 4th were read and confirmed.

Messrs. C. Morris, H. C. Cheavin, F. Rolph, S. W. Brett, H. Streatfeild, H. H. Mortimer and W. B. Boyes were balloted for and duly elected members of the Club.

The List of Donations to the Club was read and the thanks of the members were voted to the donors. Among these may be specially mentioned four preparations of the diatom *Surirella elegans*, three of these showing "girdles," and one "double valves," all prepared and presented by Mr. T. Chalkley Palmer, of Media, Pennsylvania.

The Hon. Treasurer, Mr. F. J. Perks, read a paper communicated by Mr. W. Wesché, F.R.M.S., on "The Life-History of the Tachinid Fly, *Phorocera serriventris*, Rondani, and on the Viviparous Habit of other Diptera." The author said that in 1906 he figured and described in *Trans. Linn. Soc.* the remarkable ovipositor of this fly, and in *Journal R. M. S.*, 1908, the biological problems presented by its morphology and surroundings were dealt with. At Mersea Island, on the Essex coast, he had been able during the past summer to capture and watch a number of this species. They were never very plentiful, and are difficult to recognise, and until a specimen was examined with a lens it was not possible to be certain that it was not *Blepharidea*, *Plagia*, *Frontina*, or one of the smaller *Sarcophaga*. The specimens noticed were usually seen resting on a leaf, often a bramble, and from the number taken the males were present in the proportion of two to one female. The female is provided with a relatively very large, strong, sharply pointed hook, not at all unlike a sting, which is folded back under the abdomen, and lies, when not in use, in the median line. There are also chitinous ventral plates, which are cleft, and allow the hook to rest on the soft membrane of the abdomen. The author had established the fact that *Phorocera serriventris* is viviparous, and in one preparation of a female he had counted ninety-eight jaws of larvae, a number rather larger than usual. Referring again to the ovipositor, Mr. Wesché said the question at once arises, "To what use does an insect put an ovipositor when that insect does not lay eggs?" He was now able to state that it was used to make an aperture into certain caterpillars (some six species were mentioned), into which living larvae were introduced. All the Lepidoptera preyed on are destructive to crops and harmful to various plants, and *Phorocera* must therefore be considered a useful, if cruel, insect. The parasitism of Diptera on Hymenoptera is rare compared with the constant attack of the Tachinidae on Lepidoptera. By means of the microscope it is possible to detect the viviparous condition of flies, if the specimens are properly cleared and prepared, as the hard chitinous jaws are not dissolved by potash, and are very characteristic in appearance, showing through the cleared plates of the abdomen. Notes on six species coming under this heading were given. These were: *Oliviera lateralis*, F., *Plagia trepida*, Mg., *Phorocera serriventris*, Rnd., *Phora ruficornis*, Mg., formerly described, and, for the first time, *Myioba fenestrata*, Mg., and *Siphona geniculata*, Deg.

Mr. F. J. Perks read a "Note on a Quick Method of Preparing and Staining Pollen," also communicated by Mr. W. Wesché. He said that after trying staining, and then clearing in phenol and xylol, which failed to remove the stain, the following method was adopted. The flowers collected August 1st to 15th were kept in pill-boxes till October 2nd. They were shaken on to a slip. The pollen was scraped into a heap and stained with methylated spirit, into which a few granules of methyl violet had been dissolved. The stain must not be too dark; it should be quite transparent, though violet in colour. This process lasts about a minute, several drops being added at intervals, and the slip is then placed on the hot plate. Watch carefully to see that the liquid is in every case not completely evaporated, and add a drop of unstained spirit; repeat this, and add a drop of turpentine; repeat three times, add a drop of balsam in xylol, and cover. Let the slide cool on the hot plate after extinguishing the lamp.

The President, in moving that a vote of thanks be accorded to

Mr. Wesché, said, referring to the first paper, that he had noticed in Africa that the males of the tsetse fly always exceed the number of females. This might be due to the retiring habit of the sex. The proportion observed was about five males to one female.

Mr. J. P. Wright sent a short note relating to some as yet unidentified beetles found in bales of Turkish tobacco. Turkish tobacco leaf is imported in bales, fairly compressed. When an infected bale is opened, few mature beetles are observed, but when the leaves are separated they soon make their appearance. In an infected bale the eggs, and subsequently the adult insects, are plentiful; but the larval and pupal stages are difficult to discover. The author's informant told him that "the beetles thrive merrily on naphthaline." As an experiment, some infected leaf was put into a box with a perforated false bottom, in which was put some naphthaline, and so left for some time. It was found that the beetles had left the leaf and taken refuge in the naphthaline, from which, however, they flew in clouds (!) as soon as the cover was removed. Carbon bisulphide effectually disposes of them. These beetles are not found on Indian, African, Virginian, or China leaf, but seem peculiar to the Turkish growth, and it is only an occasional bale of this kind that is so infested.

Mr. A. C. Banfield read a paper on "Low-power Photomicrography and Stereo-photomicrography." He said that he wished to draw attention to the singularly beautiful results which are obtained by applying stereoscopic methods to photomicrography, results which, in possessing the third dimension of depth or distance, tell more of the actual shape of an object in a single glance than is possible by any monocular photograph, however good. Reference was then made to the nature of a stereoscopic photograph, and to the reason that two apparently similar photographs of a given object should give such an appearance of relief when examined through a stereoscope. But the two photographs are only apparently similar, for differences between the two pictures exist, in most cases so small as to be imperceptible to the unaided eye, but nevertheless there—and it is to these minute differences, recognised by the brain, that we owe the wonderful effect of the stereoscope. The dissimilarity of the two pictures corresponds to the different impressions of an object received by each of our eyes, owing to their angular separation. It is entirely due to the separation of our eyes that we are enabled to so readily locate the position of an object in space with reference to other objects. In practice, stereoscopic photographs of ordinary objects, views, etc., are taken by means of two separate cameras, for convenience mounted parallel to each other on the same baseboard. Each camera has its own lens, the two lenses thus for photographic purposes replacing the human eyes. With reference to the separation of the two lenses, it was stated that it was the practice of makers to supply stereoscopic cameras with lenses fixed at a distance apart of about 80 mm., a distance which is absurd when it is remembered that the average interocular distance is about 62 mm. The result of this excessive but usual separation is very apparent in the distorted and uncanny sense of relief experienced in looking at the "commercial" stereoscopic views, which are on sale everywhere. The same fault is evident in many stereo-photomicrographs. The two-camera method is the usual way of preparing stereoscopic photographs, but there is another way by which they can be made, though not with the same facility—that is, by the use of a single camera. At many photographic dealers a small fitting can be obtained, which is placed between the camera and the tripod top. It consists of a small board sliding in a grooved guide fixed to the camera-tripod top. The camera is fixed to the sliding board, and an amount of movement allowed equal to the usual erroneous ocular separation of 80 mm. In practice, a photograph is taken with the camera at one end of the slide, the plate is changed and the camera moved to the other end, when the second picture is taken, the two, of course, corresponding to the right- and left-hand view. Equally good results are obtained as in the two-camera method; but moving figures cannot, of course, be included. The lecturer said that it was by an inversion of the latter method that the photographs had been prepared which he had the pleasure of showing that evening. But before describing his method in detail, he would say a few words on the mathematical principles involved. He accepted the average interocular distance as 62 mm., and this distance furnished the base for practical photomicrographic work, as the quotient obtained by dividing this distance by the desired magnification gives the correct separation of the lenses for that particular magnification. Thus, if we are photographing an object × 62, then the objectives must be separated 1 mm. ; if × 31, then the separation would be 2 mm. This rule holds good whatever type of objective is used and for all magnifications ; at 1,000 diameters the separation is 62 micra. These considerations lead at once to the root of the subject, as it will be realised that no objectives made could be placed so close together as 1 mm. It might, perhaps, be possible to get them, say, 10 mm. in diameter, and, by mounting them close together, could then work to × 6 ; but such a system would be far too inelastic for all-round work. We should want to take photographs at much higher and also lower magnifications, so other means must be sought. We find that the single-camera method referred to is suitable in every respect ; there is only one lens to consider, necessitating two separate exposures ; also the method enables us to work at any desired magnification. It is, of course, impracticable to move a long and heavy camera, such as is necessary in photomicrographic work, the often minute distance required for the objective separation ; but it is very easy to move the object we wish to photograph any required distance, great or small, by a suitable mechanical arrangement. Mr. Banfield then proceeded to describe in detail the apparatus he employed for this work, and which he had on exhibition at the meeting. It consisted of two of the well-known Zeiss optical benches placed end to end, mounted on heavy trestles. For low magnification (up to about × 10) one only gives sufficient extension. The lecturer remarked on the exceeding usefulness of these benches. At one end of the bench is fixed the lamp-casing, the bench itself carrying the condensers, object-stage, objective and camera, all of these adjustable in any position on the bench. The camera employed was adapted to the English standard stereoscopic size, $6\frac{3}{4} \times 3\frac{1}{4}$ in. The formula mentioned with regard to objective separation resolves itself in practice into two parallel lines drawn on the focussing screen 62 mm. apart. By means of the stage the object is moved till one of the lines cuts the image centrally—the first exposure is made. The image is then transferred to the other line, when a second exposure gives a truly stereoscopic pair. The objectives usually employed were Zeiss "Planar," of 20 and 35-mm. focus, and one of a similar type by Leitz, of 42-mm. focus. The last named was found very useful for such comparatively large objects as Mycetozoa, Foraminifera, etc. With regard to illumination, the lecturer preferred incident light. Stereo-photomicrographs taken by transmitted light seemed to be very unsatisfactory, through diffraction and shadow effects. Objects to photograph well from a stereoscopic point of view should be full of detail in every part. Dealing with the illuminant, the Nernst electric lamp with one ampère filament was thought most suitable, although incandescent gas is good for moderate magnification. With limelight it is difficult to get equalised exposures, as pitting of the lime frequently gives trouble. The open arc is not generally suitable, but enables very short exposures to be made. Using an open arc taking fifty ampères, fully exposed negatives had been secured with an exposure of two seconds of some aecidia on nettle-leaf × 67. With such a very powerful light, great care is needed to avoid burning the specimen, and a deep cooling trough is always used. Referring to the Lumière Autochrome plates, the speaker said it was a matter for regret that these wonderful plates were unsuitable for stereoscopic work. The trouble is not so much in the length of exposure as in the patchiness of the screen. It is found impossible in practice to mix the starch-grains, of which the tricolour filter is composed, in accordance with theoretical requirements; a number of grains of the same colour will persistently adhere to each other, these forming distinct colour blotches, which float in space over the picture proper, when viewed in the stereoscope. As photomicrographic work is usually done with an artificial source of light, the usual autochrome filter is unsuitable. A special filter is made for use with the electric arc, but the lecturer had not used it with much success, the photographs taken being too brown all over. This might possibly be due to variation in composition of the carbons used in the arc, such variations creating small differences in the colour composition of the light, to which these plates are exceedingly sensitive. A very good method of working is to convert the light from a Nernst lamp to theoretical daylight by a special blue filter made for the purpose, and then use the usual autochrome daylight filter. This causes very long exposures, but the results, some of which the lecturer showed, are well worth the extra trouble involved, as the colour rendering is as accurate as could possibly be wished.

Using a thirty-ampère arc lamp, Mr. Banfield then projected on the screen a number of photomicrographs, many of them very beautiful, especially some of eggs of various parasites and moths. A number of micrographs of polarised subjects taken on autochrome plates were also shown. A set of four, of cadmium sulphate × 350, photographed under different conditions, $\frac{1}{4}$-wave plate, first order red selenite, etc., being much admired.

The thanks of the Club were unanimously voted to Mr. Banfield for his paper and exhibition; thanks were also voted to Messrs. Angus & Co. for the loan of stereoscopes for the occasion.

Mr. C. F. Rousselet exhibited some specimens of rotifers obtained during Shackleton's Antarctic expedition in the *Nimrod.* Mr. Murray had intended to be present, to describe these objects, but was unavoidably prevented. The preparations, which were made from material obtained 15 ft. below the surface of a frozen pond, were *Adineta grandis* (sp. n.), from Ross Island, *Hydatina senta*, and two mounts of *Philodina gregaria.*

The Secretary said he regretted to have to announce the death of Mr. E. Hinton on October 10th under very painful circumstances. Mr. Hinton had been a frequent attendant at their meetings and was well known to many of the members. An expression of regret and sympathy was sent from the meeting to the relatives of the deceased.

At the meeting of the Club held on November 23rd, 1909, Prof. E. A. Minchin, M.A., F.Z.S., President, in the Chair, the minutes of the meeting held on October 26th were read and confirmed.

Messrs. Charles H. Huish, R. C. Maclean, Charles S. Bright and B. M. Draper were balloted for and duly elected members of the Club.

The List of Donations to the Club was read and the thanks of the members were voted to the donors. Among these special mention may be made of a copy of Koch's *Ubersicht des Arachnidensystems* (1837), formerly belonging to the Rev. C. R. N. Burrows and now presented to the Club by Mr. H. E. Freeman.

The Hon. Secretary reminded members of the much-regretted death, at Lee, on November 7th, of one of the Club's most distinguished members and past-Presidents, Dr. W. H. Dallinger, F.R.S., etc., at the age of 67. After being educated privately, Dr. Dallinger entered the Wesleyan ministry in 1861. In 1871 he joined the Royal Microscopical Society, and in the years 1873 to 1876, in conjunction with Mr. J. J. Drysdale, published a series of papers on the "Life-History of Monads," and in 1878 on the "Effect of High Temperatures on Flagellates." In 1880 he was elected a Fellow of the Royal Society, and from 1880 to 1888 was Governor of the Wesley College, Sheffield. In 1883 he became a member, and in 1890–1–2 was President, of the Quekett Microscopical Club. From 1884 to 1887 he was President of the Royal Microscopical Society. In 1891 he edited the seventh, and in 1901 the eighth, edition of Carpenter, *The Microscope and its Revelations.* In 1884, while at Montreal with the British Association, he received the honorary degree of LL.D. from the Victoria University, and in 1892 D.Sc. from Dublin, and in 1896 D.C.L. from Durham.

The President said that the late Dr. Dallinger was one of the greatest microscopists, both in practice and theory, that had ever lived. In conjunction with Drysdale, his method in important researches was continuous observation, and his work on the life-history of minute flagellates required the most extreme care in technique and the utmost patience in carrying out. If occasion required, his laboratory was provided with a bed, and Drysdale and he would take turns at observing some particular organism for a great many hours at a stretch. The wish was expressed that many more imitators of Dallinger might be found. His methods were much to be preferred to the usual modern custom of describing stained organisms. The world of microscopy had suffered a very great loss by Dr. Dallinger's death.

The Hon. Secretary was requested, on behalf of the Club, to send notice of a vote of condolence then passed to the relatives of the late Dr. Dallinger.

The President, Prof. E. A Minchin, exhibited under microscopes two preparations of the *Cysticercus*-stage of a tapeworm from rat-fleas. He had for some time been experimenting on the transmission of trypanosomes to the common rat by means of fleas. Having great difficulty in obtaining fleas, he offered a shilling each, but could not get them in London. He finally secured an adequate supply from Norfolk, and began breeding them in November, 1908, on tame white rats, and soon had thousands available. He found, in addition to the trypanosomes, other parasites—one which infected the Malpighian corpuscles, and another the heart of the flea, and, lastly, in the body-cavity he noticed the *Cysticerci* he now exhibited. They were easily missed, as they much resembled fragments of ovary. He found these in nearly half of the specimens examined.

All tapeworms have two stages in their life-history. The sexual worm produces eggs in the intestine of a vertebrate. This is the real tapeworm. The eggs pass out with the faeces and contaminate the food of another animal, not necessarily a vertebrate. In this intermediate host we get the bladder-worm (*Cysticercus*). As a rule, the two hosts are so related that the bladder-worm host is eaten by the host of the sexual worm. In the tapeworms most common to man, the intermediate stage is found in pork, beef and fish, and, similarly, that common in the cat comes from the mouse. The dog and rabbit are similarly placed. The President hoped to determine what tapeworm the *Cysticercus* exhibited gave rise to. He thought it was probably *Hymenolepis diminuta*.

The Hon. Secretary read a note on *Zoothamnium geniculatum*, communicated by Mr. J. Stevens, F.R.M.S., of Exeter. The writer referred to the description and drawing of this beautiful Infusorian by Mr. W. Ayrton, who first discovered it, in JOURNAL Q.M.C., Series 2, Vol. VIII., p. 407, Plate 21, December 19th, 1902. Mr. Ayrton had informed him that up to July, 1907, he had not heard of the species being found elsewhere than in the locality of the River Waveney, Suffolk. The writer, however, had found it in 1907, 1908, and on October 30th this year in the River Exe and neighbourhood. Mr. Ayrton says that the specimens forwarded to him are undoubtedly *Z. geniculatum*.

Mr. F. P. Smith communicated a "Note on the Mounting of Spider Dissections as Microscopical Objects." The author said he offered a few hints as to a means whereby slides may be prepared in which the form and structure of the objects concerned are faithfully preserved and exhibited. He insisted that the effect of the attempt to "clear" a spider with liquor potassae or any similar reagent is promptly to ruin it so far as systematic work is concerned. The integuments of the body are generally very deficient in chitin, and become hopelessly transparent when treated with an alkali, whilst the male palpus, the form of which is of paramount importance in the identification of species, is almost invariably distorted by any attempt at clearing. Apart from alkaline treatment, any pressure of the cover-glass must be regarded as fatal. It is very necessary to preserve the mounted dissection in as nearly as possible the same condition as the unmounted object. It often happens that one possesses a solitary example of a rare and obscure spider, and may have occasion to compare it, time after time, with specimens more recently captured, or received from correspondents. This means, under ordinary conditions, the removal of the specimen from its tube of spirit, with much consequent damage to legs and spines. The mounting of such a specimen, or of some important portion of it, upon the orthodox 3 by 1 slip is clearly an advantage, provided that (1) it can be so mounted as not to disturb the relative position of its component parts or alter their form; and (2) that it can be mounted permanently, or, if not, that it can be expected to keep in good condition for a reasonably long period, and further, that it can, should the mount deteriorate, be remounted without more trouble or risk than that involved in the original process. The procedure is as follows. The spider, when caught, is killed by immersion in whisky. Mr. Smith said that some one will probably ask, "Why not brandy?" There was no reason, except that when he commenced the work there happened to be a bottle of whisky in the house, and he "purloined" sufficient for his first experiments. Finding these successful, he continued to use it. If a preserved spider is to be dealt with, the palpus is removed and soaked in whisky for an hour or so, presuming that the specimen has been suitably preserved in methylated spirit. Material used consists of glass slips with ½-in. circular excavated cells and some tin cells of ¾-in. diameter and various thicknesses, with cover-glass to match. The cells should be ground perfectly flat upon each side. This is easily accomplished by glueing a sheet of emery-cloth upon a smooth board, and rubbing the cell upon it by means of a large cork or flat piece of indiarubber. The slips must be scrupulously clean. If at all greasy, a little liquor potassae will be found useful. The following reagents, which should be brought to exactly the proper consistency for easy working by the addition of their respective diluents, are required: gold-size, caoutchouc cement (Miller's), and Club black. As a mounting medium, use equal parts of whisky and glycerine. This should be carefully filtered, or else allowed to stand for a few days, and then decanted. Place a slip on the turntable, and run upon it a ring of gold-size $\frac{3}{4}$-in. diameter. Take a cell, and, by means of a pair of forceps, drop it on the ring of gold-size, pressing down to ensure good contact. Prepare a number of these slips, using cells of different depth, and put aside for a week to dry.

Take the whisky-soaked palpus and place it in one of the deepest cells, fill up with whisky, and place a temporary cover-glass upon it, holding it in position with a wire clip. Now turn the slide about and observe what happens. If the cell is very deep compared with the thickness of the object, this latter will fall to the side. If somewhat shallower, the object will only reach the margin, or near to the margin, of the now practically invisible excavation in the slip. Try cells of various depths until one is found which produces the desired result, which is to keep the object perfectly still, or else to allow it only a certain amount of movement. The proper slip having been found, it is thoroughly cleaned, placed upon the turntable, and a ring of caoutchouc cement run upon the upper surface only of the tin cell, and then allowed to dry for, say, a quarter of an hour. The cell is filled to overflowing with the glycerine-and-spirit mixture, the dissection is introduced and arranged, and a cover-glass put on and held in position with a weak wire clip. The whole is held under a gentle stream of water from a tap, in order to get rid of every trace of glycerine from the glass. The success of the process depends upon this being thoroughly accomplished. To avoid the inrush of a bubble of air when the clip is removed, perform this operation under water, and allow the slide to remain submerged for a few minutes. A small quantity of water will enter, but will not in the least impair the mounting medium. The mount is then wiped as far as possible, allowed to dry thoroughly, a ring of gold-size is added, and, a couple of days afterwards, a ring of Club black. In a considerable number of preparations, dating back for more than two years, not one air-bubble has penetrated, in spite of a good deal of very rough usage.

Mr. J. S. Dunkerly, B.Sc., gave "A Résumé of our Knowledge of the Choanoflagellata." He said that these organisms, owing to their minute size, are a little-known group of the Protozoa. Early microscopists described forms possessing three processes, probably identical with collar boundaries and flagellum. J. Clark, in America, was the first to describe the true structure of these forms, and Saville Kent described most of those at present known, later workers being Bütschli, Entz and Francé. Fisch has described the process of reproduction by division.

A typical Choanoflagellate has an oval, naked protoplasmic body with nucleus, contractile vacuole, one flagellum, and surrounding the base of the flagellum, a protoplasmic membrane—the collar, which is usually basin-shaped. Food particles are brought into the region of the collar by the movement of the flagellum. Saville Kent described such food particles as passing down inside the collar to be absorbed by the body-protoplasm, but later workers are of opinion that the current passes down outside the collar. Food vacuoles may be seen at the base of the collar. The flagellum arises from a staining granule, the blepharoplast, which, apparently, was not seen by Saville Kent and other early workers. In division, the flagellum is retracted; the collar sometimes divides, if not also retracted. Cysts have been observed to give rise to flagellate individuals, which swim freely and gradually acquire a collar.

The simplest naked form is *Monosiga*; a similar form, but on a branching stalk, is *Codonosiga*. The genus most rich in species is *Salpingoeca*, a form living in a lorica, or case, secreted from its body. There are various beautiful forms of this "house." A similar form, in which, however, the individuals have their houses connected with each other by stalks, is *Polyoeca*, a rare form observed by Saville Kent in aquarium tanks at Hastings. The lecturer had also noticed it occurring in tanks at Plymouth Biological Laboratory. *Proterospongia* is an interesting form with a gelatinous body, in which are embedded collared cells and amoeboid cells. Saville Kent considered the sponges to be derived from a similar form, but our present knowledge of sponge development renders this very unlikely. Some double-collared forms which have been described resemble loricate forms, in which the neck of the lorica may have been mistaken for a second collar.

The relationships of Choanoflagellata are obscure; possibly *Bicosoeca* is an intermediate form. Mr. Dunkerly illustrated his remarks by a number of diagrams on the blackboard.

Replying to questions by Mr. Hilton and Mr. Scourfield, the lecturer said that during division the flagellum is retracted and developed from each new individual. Encystment had been observed, and the spores, on development, swim off as separate Choanoflagellates. Whether the process was sexual was not known. The direction of movement of the free-swimming forms was with the flagellum behind. If otherwise, the distended collar would greatly impede progress. This method was quite exceptional and only obtained directly after division, as the collar had not then been developed. In the movement of such individuals the flagellum was anterior.

Mr. H. S. Cheavin sent for exhibition some enlargements of photomicrographs of insect dissections.

Mr. A. E. Hilton exhibited (× 25) a preparation of the Mycetozoon *Arcyria albida*, showing the sporangia breaking down, the spores scattering and capillitium protruding. The specimen was found growing on rotten wood.

The President said he had to thank Messrs. Watson for the loan of the two microscopes employed for his exhibits.

At the meeting of the Club held on December 28th, 1909, Prof. E. A. Minchin, M.A., F.Z.S., President, in the Chair, the minutes of the meeting held on November 23rd were read and confirmed.

Messrs. J. Bostock, G. N. Higginson, F. C. Dumat, S. W. Knox, J. Shephard and H. C. Gooding were balloted for and duly elected members of the Club.

The List of Donations to the Club was read and the thanks of the members were voted to the donors.

Mr. R. T. Lewis, F.R.M.S. (Hon. Reporter), read a note on "The Pollination of the Asclepiads." He said that early in 1909 he received some insects from a correspondent at Lindley, in the Orange River Colony. Adherent to the feet of one of the Hemiptera, and to those of two of the larger Hymenoptera, were some small yellow objects, which at first sight were thought to be particles of the material in which the insects had been packed. A camel's-hair brush failing to remove them, they were examined under the microscope, when it was at once seen that they were of vegetable origin, further investigation proving that they were the dried pollen sacs of some species of Asclepiad. Their adherence was so firm that a knife had to be used to remove them; after being saturated with xylol and mounted in Canada balsam they became translucent, and their minute structure was readily seen. They were of elongated pear shape, greenish yellow in colour, and occurred in pairs attached at their narrow ends to a dark-brown base, of more rigid structure, formed of two short processes united at one end, the division between these forming a kind of clip, by which they were firmly affixed to the pulvilli or spinous hairs on the feet of the insects. Attempts to mount them *in situ* were not attended with success, since the pollen sacs absorbed fluid very easily, and, becoming softened, detached themselves from the clips before these and the feet of the insects were sufficiently soaked to be further dealt with. Whilst in the dry state the pollen sacs were more or less shrivelled, giving a very imperfect idea of the general arrangement. Unfortunately, Mr. Lewis said, the best example for dry-mounting slipped from the forceps in which he was holding it and got lost upon the floor, and the only remaining specimen was exhibited under a binocular microscope then on the table. Another microscope showed very well under higher magnification a preparation of a pair of pollen sacs with the clip. Several examples of the feet of insects with the clips fastened upon them were also shown.

Mr. Lewis then read an interesting extract, referring to the Asclepiads, from Kerner and Oliver's *Natural History of Plants*, vol. ii. pp. 257–9, two figures from which he had copied and exhibited in illustration of his remarks.

Replying to a question as to the size and colour of the flower of *Araujа albens*, Mr. Lewis said they were about the same size as the cultivated hyacinth, growing three or four on a stem, and hanging down. In Cape Colony they were pink in colour, but in the Orange River Colony they were white.

Mr. R. Paulson, F.R.M.S., said that a similar habit had been noticed in *Vincitoxicum*, a shrubby plant about 18 in. high, with rather inconspicuous yellow flowers. It was common in

Western Europe, and he had found it in Southern France, Belgium, and quite commonly in Switzerland.

The President said that the relation of insects to pollination was a very interesting subject. Last summer, while in a small town in Southern France, some five miles from the Spanish frontier, he noticed a creeper, a species of Asclepiad, growing on a railing, and from one of the inconspicuous flowers observed a specimen of the humming-bird hawk moth, *Macroglossa stellatarum*, hanging by its proboscis. He had recently seen in a number of the *Comptes Rendus* a paper on the subject, giving numerous instances where dead insects have been found hanging from various Asclepiads by their probosces.

Mr. W. Wesché, F.R.M.S., said he did not understand how insects like the wasp, with short probosces, got trapped. Those with long ones like *Macroglossa* it was easy to understand.

Mr. A. E. Hilton exhibited (× 20) sporangia of *Didymium effusum*, on a dead leaf. A species very variable in form.

Mr. W. Wesché, F.R.M.S.: Mites in *Cryptops hortensis* (Garden centipede).

Mr. J. Burton: Young Nostocs, probably *N. caeruleum*, from Ruislip.

At the meeting of the Club held on January 25th, 1910, Prof. E. A. Minchin, M.A., F.Z.S., President, in the Chair, the minutes of the meeting held on December 28th, 1909, were read and confirmed.

Messrs. F. W. Green, J. A. Carter, R. Canaway, E. Cross, H. Whitehead, A. E. Hammond, S. C. Sheldrick, C. S. Todd and J. S. Crabtree were balloted for and duly elected members of the Club.

The List of Donations to the Club was read and the thanks of the members were voted to the donors.

Nominations for officers and members of the Committee for election at the annual general meeting, to be held on February 22nd, were taken.

An account of the fresh-water organisms taken during the Antarctic expedition under Lieutenant Shackleton was given by Mr. James Murray, one of the scientific staff on board the *Nimrod*. Four specimens of rotifers were exhibited. These were *Philodina gregaria*, *Philodina alata*, *Adineta grandis*, sp. n., and

Hydatina senta. That he was able to show any mounted specimens at all was due to Mr. C. F. Rousselet. Those brought home were not very efficiently mounted, and Mr. Rousselet remounted them. Generally speaking, the rotifers are not very peculiar, perhaps the most notable being *Philodina alata*, which has large lateral processes. Referring to *P. gregaria*, Mr. Murray said that in the localities examined this species was remarkable for the extreme abundance in which it was found—this abundance being due to its rapid multiplication, as many as six living young being produced at a birth. It forms blood-red stains on the pebbles in the lakes, and a bottle containing a filter-paper stained brilliant red was shown to the meeting. The coloration was due to the presence of myriads of this species of rotifer. It was obtained in the following manner: A handful of the vegetation was washed in water and the sediment thus obtained was transferred to a bottle. After a while the rotifers came to the surface of the mud, where they formed a blood-red film. A little later they crept up the sides of the bottle till they reached the surface of the clear water. They there formed a crimson ring, and could be easily removed to a filter-paper by inclining the bottle till part of the ring was clear of the water, and lifting the animals by means of a camel's-hair pencil. The filter-paper was then dried and preserved. Photomicrographs of living narcotised specimens of *Philodina gregaria* were exhibited, and also of several other Rotifers, Tardigrades, and Infusorians. Two new species were mentioned, both belonging to the genus Philodina, *P. antarctica* and *P. alata*.

Much interest attaches to the mode of life of these organisms. The air temperature in latitude 77° to 78° South hardly ever rises above freezing-point. This does not favour a great growth of moss, nor of the rotifers which live upon it. They find a home in the lakes, which, though frozen for ten months of the year, attain to a temperature of as much as 60° F. in summer. There was shown a specimen of the Antarctic vegetation amongst which the animals are found. It is orange-coloured and in large thin sheets, many of which are superposed to form a stratum of considerable thickness, covering small ponds without interruption from side to side. The underside of the sheet is dull green from the presence of numerous algae, green and blue-green.

The rotifers do not die when the lakes freeze, but go to sleep and wait for the next thaw. This may not come for years in those deeper lakes which do not melt in ordinary summers. But even in one of these, under fifteen feet of ice, rotifers were numerous. It was found experimentally that these organisms are able to withstand greater heating and greater cooling than they ever experience naturally. It is especially noteworthy, as bearing on their dispersal over the region, that they were not killed by sea-water, nor by a much more saline fluid found in some small lakes.

Mr. W. Wesché, F.R.M.S., said he would like to ask the lecturer whether he could do anything to clear up the vexed question of the males of bdelloid rotifers. Then, again, in the viviparous forms, are the young born one after the other or all at one time? It was very interesting to watch, say, *R. vulgaris* in a compressor, and see the young ones shoot out and begin life on their own account. Were other rotifers besides bdelloids experimented on as regards temperature-resisting ability?

Mr. Murray, replying, said that no male bdelloid had been found. As regards the viviparous habit, he had but rarely observed this. He thought that when a compressor was used, it introduced conditions certainly not natural. The experiments had been confined to bdelloids.

Mr. J. Burton, referring to the specimen of undetermined vegetation exhibited, suggested that it might be a symbiotic union between a fungus and an alga, practically amounting to a lichen. It might be that a symbiotic union between such organisms would enable them to live under conditions neither of them could endure apart. He noted that the material shown split into small laminae. Was it likely that each sheet represented one year's growth?

Mr. D. Bryce said that perhaps the most remarkable point mentioned by Murray with regard to Antarctic Rotifera was the occurrence of two viviparous species belonging to Bdelloid genera, which, so far as they are yet known, are always oviparous in places where such extreme cold has not to be experienced, and it was particularly noteworthy that in these two species the embryos seemed to be matured in batches, not successively. It is a general rule among bdelloids that the two ovaries alternately produce ripe eggs. In *R. vulgaris* the female may be observed to contain a number of embryos of different stages of growth.

He had observed some cases where the female had been unable to extrude the ova at the proper time. He had noticed this in one instance of a *Callidina constricta*: he found some large females containing, instead of a single ovum, four or five, in various stages of growth, several of these showing the mastax already developed. Now, ordinary segmentation even does not occur till several hours after extrusion of the ovum, but in this instance—a most remarkable case—it had so far advanced that the organs began to be visible. It was probably due to some pathogenic condition—something had happened which had prevented the female from extruding the ova at the proper time. It was a most interesting point that species of a genus usually oviparous should have developed the faculty of bringing forth young alive. The egg-laying faculty was of course due to the fact that it was desirable for the species to survive desiccation. As regards the males of bdelloid rotifers, these had not yet been found, and, he thought, never would be found. He thought the Club should congratulate Mr. Murray on his safe return from a very dangerous expedition, and that they might congratulate themselves on having listened to so interesting a lecture.

Mr. Murray, replying, said that the lichen-equivalent suggestion had been made before. The material had been submitted to a professor of botany, who was examining it, but could not yet express an opinion. On the under-surface of the sheets there was almost always a great number of mixed algae.

Mr. C. F. Rousselet, F.R.M.S., after expressing his appreciation of Mr. Murray's lecture, said it was very remarkable for *Hydatina senta* to be found in the Antarctic. He was interested to hear that it could stand freezing. Among the material brought back he had found, besides bdelloids, specimens of *Floscularia ornata* and *Melicerta ringens*. He believed that Mr. Murray was the first to investigate the pond-life of the Antarctic.

The President, in moving that a very hearty vote of thanks be accorded to Mr. Murray, said that it was a great privilege for the Club to hear papers of this kind. The facts they had heard as to the life of organisms in this region were most extraordinary. It would be interesting to ascertain the extremes of temperature that these organisms could stand. The thanks of the Club were also due to Mr. Rousselet for mounting the specimens, and to

Messrs. Baker for lending the microscopes employed in exhibiting the preparations.

Mr. A. E. Hilton exhibited (× 20) sporangia of *Badhamia utricularis*, on fungus, mounted dry. The following notes were given :—The specimens mounted were cultivated from sclerotium in 1907. The developments observed were : April 13th—Plasmodium began to spread from moistened sclerotium ; it was fed with fungus (*Stereum hirsutum*), and grew rapidly—faster in the warmer weather than when it was colder. May 11th—Plasmodium began gathering up for spore-formation. May 15th—Sporangia had formed, and were bright yellow in colour. May 16th—In the morning they were coal-black ; by evening, purple-black. May 18th—Sporangia had assumed their final iridescent, cinereous hue.

At the meeting of the Club held on February 22nd, 1910, Prof. E. A. Minchin, M.A., F.Z.S., President, in the Chair, the minutes of the meeting held on January 25th were read and confirmed.

Messrs. W. S. Doughten, L. R. McCulloch, E. C. Joshua, F. C. Fuller, A. G. Hammond, J. W. Gordon, N. Simpson and F. H. Lewis were balloted for and duly elected members of the Club.

The List of Donations to the Club was read and the thanks of the members were voted to the donors.

The Hon. Secretary, Mr. W. B. Stokes, read the Committee's 44th annual report. The number of members on the books on December 31st, 1909, was 455, practically the same as last year.

Reference was made to the much-appreciated services of Mr. F. P. Smith, for six years Hon. Editor of the JOURNAL, and a special vote of thanks was passed by acclamation, and at the same time much regret was expressed at the announcement of his resignation of that office.

The Hon. Treasurer, Mr. F. J. Perks, presented his report for the past year. The balance in hand, within a few pounds, was practically as last year. He considered the financial position of the Club satisfactory. With the following exceptions, the officers of the Club are the same as last year—Mr. D. J. Scourfield, F.Z.S., F.R.M.S., becomes Vice-President, in place of

Mr. H. Morland retired, and Mr. A. W. Sheppard, F.R.M.S., Hon. Editor, vice Mr. F. P. Smith, resigned.

Mr. C. F. Rousselet, F.R.M.S., Vice-President, having taken the Chair, the annual address was delivered by the President, who dealt with "Some Considerations on the Phenomena of Parasitism amongst Protozoa."

The address was illustrated by a number of coloured diagrams and drawings.

The Chairman, Mr. C. F. Rousselet, in asking the Meeting to pass a very hearty vote of thanks, said that the President had given them a most interesting address, and he hoped permission would be given for it to be reproduced at length in the JOURNAL. The subject was a very difficult one to discuss. Referring to some parasites which produced no disease, the Chairman said there were certain sporozoa which infested rotifers, and he had frequently found the bodies quite full of sausage-shaped parasites; but they were apparently not harmful. When recently in Canada he had heard it suggested that the extinction of the vast numbers of buffalo was caused by some peculiar parasitic malady.

The President having replied, the usual votes of thanks to the officers and members of Committees for their services during the past year were carried.

FORTY-FOURTH ANNUAL REPORT.

During the past year little has occurred to modify the optimism which has been for so long a feature of your Committee's Annual Reports.

In the twelve months ending December 1909 thirty-five new members were elected, being three less than in 1908. The average for the period 1899–1908 was 43·8. The Club loses fourteen members by resignation and seven by death, leaving a net gain for the year of fourteen. The number of the members on the books at the end of the year was 455.

Of those members removed by death, Mr. James Neville and Mr. E. Hinton were frequent attendants at the meetings; the Club also has to deplore the loss it has sustained, with the scientific world in general, by the death of the Rev. Dr. William H. Dallinger.

The attendance at the meetings has been well maintained, the conversational evenings being better attended than for some time past. In April an alteration was made in Rules I. and IX. to allow for a change in the day of the week on which meetings are held. This was brought about by the necessity of entering into a new agreement with the Club's landlords. By their new agreement the Club has the use of the large room on the 2nd and 4th Tuesday evenings of each month for a number of years, together with other privileges duly set forth. This is more than the Club was entitled to under the former agreement, and it has been obtained without any increase of rent. Your Committee wishes to express its thanks to the Hon. Treasurer for the services he has rendered in connection with the execution of the agreement. The necessary alteration in the Club's arrangements is bound to be inconvenient to some members, but your

Committee is gratified to note that the inconvenience is confined to few.

Your Committee has again to deplore the fewness of papers containing original work, and it is feared that unless this falling off be arrested the character of the ordinary meetings and of the *Journal* will deteriorate. Although prompt publication cannot always be guaranteed, the main results of any work appear within a fortnight in the pages of *The English Mechanic,* and are sent to all country members.

During the year the following communications have been received:

PAPERS.

March. The Structure of the Eye-surface of Diptera, etc.
Mr. W. Wesché, F.R.M.S.

,, On *Holostomum excisum.*
Mr. T. B. Rosseter, F.R.M.S.

,, On *Hymenolepis acicula sinuata,* sp. nov.
Mr. T. B. Rosseter, F.R.M.S.

April. On a New Species of *Technitella.*
Messrs. E. Heron-Allen, F.L.S., F.R.M.S.,
and Arthur Earland.

May. Some Applications of Microscopy to Modern Science and Practical Knowledge (Presidential Address).
Prof. E. A. Minchin, M.A., F.Z.S.

Oct. On Low-power Stereo-photomicrography.
Mr. A. C. Banfield.

,, On the Life-history of a Tachinid Fly.
Mr. W. Wesché, F.R.M.S.

NOTES.

Nov. On Mounting Spider Dissections.
Mr. F. P. Smith.

,, On a Quick Method of Preparing and Staining Pollen.
Mr. W. Wesché, F.R.M.S.

Nov. On the Occurrence of *Zoothamnium geniculatum.*
Mr. J. Stevens.

" A Short *Résumé* of our Present Knowledge of the Choanoflagellata.
Mr. J. S. Dunkerly, B.Sc.

Dec. On the Pollination of an Asclepiad.
Mr. R. T. Lewis, F.R M.S.

The following LECTURES were also given :

Feb. Estimating Exposures in Photomicrography.
D. J. Reid, M.B., C.M.

April. The Relation between Microscopic Structure and Properties of Alloys.
Mr. E. F. Law.

June. Romance of Forest Life.
Mr. F. Martin Duncan, F.R.P.S.

DEMONSTRATIONS AND EXHIBITS.

Jan. Arenaceous Foraminifera.
Mr. A. Earland.

Feb. The Making of a Microscope Objective.
Mr. F. W. Watson Baker, F.R.M.S.

April. Illuminants for the Microscope.
Mr. C. Lees Curties, F.R.M.S.

Oct. Antarctic Rotifers.
Mr. C. F. Rousselet, F.R.M.S.

Nov. Cysticerci from the Rat-flea.
Prof. E. A. Minchin, M.A., F.Z.S.

APPARATUS.

Jan. The "Club" Portable Microscope.
Messrs. W. Watson & Sons.

March. The New "D.P.H." Microscope.
Mr. C. Baker.

Nov. Quekett's Dissecting Microscope.
Mr. Webb.

Your Committee wishes to thank the authors and exhibitors for their communications and the exhibits they have so kindly provided, several of which must have necessitated much expendiof time and labour for their production. The prestige of the Club outside its own walls is very largely dependent on the quality of its printed matter, and the Committee will welcome and do all in its power to assist members submitting their investigations to the meetings.

The Excursions during the year were considerably interfered with by bad weather, and in many instances it was impossible to carry out the programme arranged for. The notable exceptions were those to the Botanic Gardens and to the Surrey Commercial Docks, where the attendance was thirty-five and thirty respectively. The average attendance at the excursions was eighteen, which is below that of recent years, but good under the circumstances. No particularly valuable captures are recorded, but the specimens obtained were sufficient amply to reward and interest those taking part in the Excursions.

By the kindness of the Editor some details have been published in *The English Mechanic* after each Excursion, and several of these reports are incorporated in the Proceedings published in the November number of the *Journal*. A pleasant incident to record was the presence on July 10th of Dr. Penard, of Geneva, our honorary member, who genially participated in the spirit of good fellowship for which the Excursions are remarkable. It is hoped that in the coming season the new members will join the Excursions as often as possible, as they afford not only a means of acquiring experience in the methods and results of an interesting branch of microscopy, but also give an opportunity for social intercourse and the exercise of that mutual assistance for which the Club has always been noted. The Hon. Secretary of the Excursions Committee will at all times be pleased to answer inquiries and give information respecting the arrangements. The thanks of the Club, as in previous years, are due to the Directors of the Royal Botanic Society, the Surrey Commercial Docks and East London Waterworks for kind permission to visit their enclosures.

The Library has proved as useful to members as ever, and is kept supplied with the publications of other Societies, of which the following is a list :

Quarterly Journal of Microscopical Science.
Annals of Natural History.

Memoirs, Reports, and Proceedings of—

Royal Microscopical Society.
Smithsonian Institution.
American Microscopical Society.
Manchester Literary and Philosophical Society.
Manchester Microscopical Society.
Royal Institution.
British Association.
Geologists' Association.
Natural History Society of Glasgow.
" " " *Northumberland.*
Hertfordshire Natural History Society.
Essex Naturalist.
Bristol Naturalists' Society.
Royal Institution of Cornwall.
Academy of Natural Science, Philadelphia.
Royal Society of New South Wales.
Botanical Society of Edinburgh.
Indian Museum (Calcutta).
Croydon Natural History Society.
Botanical Gazette (U.S.A.).
Philippine Journal of Science.
Mikrokosmos.
Die Kleinwelt.

Also the following donations to the Library have been received—

Photo-micrography (2nd edition), W. Bagshaw.
Ubersicht des Arachnidensystems, Koch.
Estudos sobie Ixodidas do Brasil.

The Hon. Curator reports that the demand for the loan of slides continues to increase, and during the past year some seventy preparations have been added to the Cabinets by donation and purchase. These consist principally of Fresh-water and Marine Algae, which section has been revised and rearranged. An increasing interest has been taken in petrology, and a further series of slides, with descriptive and illustrated notes, has been kindly arranged by Mr. C. H. Caffyn, to whom the best thanks of the Club are due. The Club is also indebted to Mr. C. H. Bestow for his great assistance to the Curator in the issue of slides. During the coming year the Curator hopes to revise and amalgamate the entomological preparations available, and asks for the co-operation of members to further this object by means of donations.

Accounts of the Club's proceedings and abstracts of the papers read at the meetings are published in *The English Mechanic* during the week following, and are sent to all country members residing more than twenty miles from London. The Club owes its best thanks to the editor for this great advantage. In *Knowledge* also appears an account of the Club's meetings, a privilege which your Committee wishes to acknowledge with gratitude.

With the November number the Journal completes the tenth volume of the present series. Your Committee records with great regret that this number also marks the termination of the services as Honorary Editor of Mr. Frank P. Smith, who has occupied that post for six years. Mr. Smith has given much time and energy to the task of maintaining the high character of the *Journal*, and your Committee wishes to acknowledge his success and its gratitude for his services.

Your Committee is glad to announce its good fortune in securing the services as Editor of Mr. A. W. Sheppard, F.R.M.S., whose experience and knowledge of systematic biology will be of great value to the Club.

Finally, your Committee desires to thank the officers for their services during the past year, and to beg all members to join them in the endeavour to further the interests of the Club and to secure its prosperity in the future. There are many ways of doing this, which in some degree are in the power of every individual member. Those members possessing special knowledge can assist both Secretary and Editor very materially ; others, with time to spare, might help in many ways, and, again, those whose only conscious quality is sociability might help new members to find that relation to their environment which has been enjoyed by so many in the past.

THE TREASURER IN ACCOUNT WITH THE QUEKETT MICROSCOPICAL CLUB

For the year ending December 31st, 1909.

DR.	£	s.	d.	CR.	£	s.	d.
To Balance from 1908	255	11	6	By Rent	75	0	0
,, Subscriptions	152	10	0	,, Expenses of *Journal*	100	7	0
,, Dividends on Investments	12	14	8	,, Postages	4	13	11½
,, Sales of *Journal*	15	2	11	,, Printing and Stationery	9	5	9½
,, Sales of Catalogues	1	8	0	,, Attendant	6	0	0
,, Advertisements	27	15	0	,, Petty Expenses	6	13	6
,, Royalties	1	9	0	,, Books, etc.	13	0	11
				,, *English Mechanic*	6	3	2
				,, Balance in hand	245	6	9
	£466	11	1		£466	11	1

INVESTMENTS.

	£	s.	d.
2½ per cent. Consols	200	0	0
Metropolitan Water Board Stock	100	0	0
2½ per cent. Metropolitan Consolidated Stock	100	0	0
2½ per cent. Annuities, 1905	100	0	0

We have examined the above Statement of Income and Expenditure and compared the same with the Vouchers in the possession of the Treasurer, and have verified the Investments at the Bank of England, and find the same correct.

February 8th, 1910.

RICHARD INWARDS } *Auditors.*
C. H. CAFFYN

FREDK. J. PERKS, *Treasurer.*

THE LIFE-PHASES OF MYCETOZOA.

By A. E. Hilton.

(*Read April 26th*, 1910.)

In his *Monograph of the Mycetozoa* (1894) the late Mr. Arthur Lister expressed his belief that the number of species already known was not likely to be largely added to by gatherings from any hitherto unsearched regions; and in the first volume of *The Cambridge Natural History* (1906) Dr. Marcus Hartog observed that with the exception of one species (*Fuligo varians*), which is a pest in tan-pits, the interest of the group is entirely biological. These remarks, taken together, testify to the fact that within the convenient limits of a comparatively small group we have an exceptional opportunity for studying life-phenomena, by reason of the processes being less obscured than in many other organisms.

Briefly, the life-cycle of the Mycetozoa has three principal phases—an aquatic, an amoeboid, and a spore-forming stage.

In the aquatic stage the individual swarm-spore is a speck of plasm, with nucleus, vacuoles, and a flagellum so small that to be seen clearly a magnification is necessary of from 500 to 1,000 diameters. At times the swarm-spores move about in the water with great rapidity.

In the phase which follows, which is usually aquatic only at the outset, a plasmodium is formed by the fusion of many swarm-spores, this process being a distinguishing characteristic peculiar to the Mycetozoa alone. Amoeba-like, the plasmodium creeps about within the substance of decaying wood or upon other rotting vegetation, on which it feeds. At this stage it may be either microscopical in size or spread over a considerable surface in the form of an irregular and extended network with a constantly changing outline. To keep it mobile, air and moisture are both essential; but as it matures it develops a tendency to leave the damper and seek the drier places, where it concentrates and comes to rest.

Then it passes into the spore-forming stage. The plasmodium is gathered up into sporangia, often resembling microscopical fungi, each sporangium containing multitudinous spores. This may be called the dry phase, as the spores escape in the form of very fine dust. When the spores become immersed in water the plasm within them expands by absorption, the fragile shells are ruptured, the plasm-specks emerge as swarm-spores, and the aquatic phase recommences.

Besides these principal stages there are minor changes, subsidiary or contingent. Swarm-spores multiply by bipartition, the process in some cases, if not in all, being repeated. After dividing, they renew their activities. Some become encysted for a while, but presently escape from their shells, without having divided, and resume their movements. The plasmodia also pass at times into a resting-stage, in which they may remain dry and brittle for months, becoming mobile once more when there is again sufficient moisture. These subsidiary changes, however, we may regard as incidents in the life-cycle rather than phases of it.

We see, then, that in the main the continuous life-history of Mycetozoa presents us with a series of alternations, in which numbers of plasm-specks (swarm-spores) blend together into amoeba-like plasmodia, and these larger masses divide into innumerable plasm-specks, which recombine as before; and so on endlessly. It is likewise plainly apparent that these alternations depend on varying conditions of the presence or absence of moisture. But we also perceive—and for our present purpose this is most important—we perceive quite clearly that the essential life-history of Mycetozoa consists, not in the various forms assumed at different stages of progress, but solely in the alternating tendencies of the plasm which produces them. Let me repeat that not in the variety of forms assumed, but in the tendencies of the plasm itself, lies the true inwardness of the life-phases of Mycetozoa.

Yet the species, numbering less than three hundred, into which this small group is divided display their full share of that striking diversity of shape and colour which makes the study of Nature at once so fascinating and bewildering. Moreover, the classification of the group is largely based upon highly microscopical details of structure, which are fairly constant. How, then, it may be asked, can these constantly recurring forms, often very beautiful, be regarded as of only secondary concern? The answer is clear. Details which are useful enough for classification purposes are often of little importance in biology; and in the case of Mycetozoa the characters at present relied upon for classification are features of death rather than phases of life. They are, in fact, but the dead casts and perishing excreta of the plastic substance which deposited them while passing on to its next phase.

For example, on the spores, which to the eye look like fine powder, and also on the very fine threads or fibres known as capillitia, among which the spores are usually embedded in the sporangia, there are markings so delicate as frequently to require a $\frac{1}{12}$-inch objective to make them out distinctly. These. with other more visible characteristics, are the best basis of classification yet discovered. But that these are not living characters becomes evident when the spores escape from the sporangia and the plasm-specks escape from the spores, for then the lifeless threads and broken spore-cells, with all their delicate sculpture, are left to decay.

It is certain, of course, that these microscopical details of the spores and capillitia are profoundly significant of something, otherwise they would not recur with sufficient regularity to furnish any basis of classification whatever. Obviously the constitutional differences which distinguish the plasm of one species from that of another have their inevitable effect, and leave their distinctive stamp upon the by-products of the organism; but that is a problem of physics rather than biology, because it involves the deeper question of the constitution of all matter, living or dead.

Returning to our study of the plasm, which presents in an extraordinary degree the opposite and alternating phenomena of fusion and division, regulated by conditions of moisture and dryness, we notice, in the next place, an alternation of another kind, connected with the food-supply. The plasm passes through periods of assimilation, causing growth, but leading to congestion and sluggishness; and such periods alternate with times of elimination of undigested substances, and consequent recovery of energy. Beginning with the swarm-spores, which apparently feed on bacteria, and probably also on other substances in solution, assimilation is carried on during the miscellaneous foraging of the creeping plasmodium, and continues until a point is reached at which congestion brings the process to a standstill. Then, in the spore-forming stage, the action is reversed, and the plasm is relieved by the excretion of its impedimenta, which are deposited as substrata, stalks, capillitia, sporangium walls, or spore-shells. In the matured spores the purified plasm, in a condition of renewed vigour, waits in readiness to resume the exercise of its motile powers as soon as the necessary conditions afford opportunity.

In the meantime, this sporangial or dry phase of the life-cycle possesses features of peculiar interest. Bear in mind that practically the whole of the purified plasmodium passes into the spores. In the process a plasmodium may produce some hundreds of symmetrical sporangia, or fewer and larger ones of irregular shape, known as plasmodiocarps, or single, cushion-like forms, aethalia, which may be several inches across. In any case, however, the dust-like spores are so minute that in a small sporangium the number is probably not less than fifty thousand, while in the larger forms they may exceed a billion. All the spores of Mycetozoa are spherical or nearly so, and those in a sporangium are usually of such uniform dimensions that the size of them is a valuable guide in determining the species. Each spore contains a tiny speck of plasm, with a single nucleus, in a more or less central position.

This means that the resting-stage at which the plasm arrives when spore-formation is complete is a condition of equilibrium. The multiplication of nuclei, which begins with the division of the swarm-spores, increases enormously in a growing plasmodium; and there is a further multiplication of nuclei in the purer plasm immediately before the spores are formed. So far, however, the plasm has been in a state of disturbed equilibrium, the stress of which largely explains its restlessness. The lively movements of swarm-spores, the reversing currents which stream through the veins of the plasmodium, and pulsations observable in immature sporangia, are vivid expressions, on a larger scale, of the oscillations which underlie them. The phase of actual spore-formation is essentially the regaining, for a time, of equilibrium which has been lost; and the mass of uniform spores into which the whole of the purified plasm has passed is the geometrical expression of this balanced condition.

There now comes to light another important fact. The final act of the plasm while settling down to equilibrium is a last process of purification, resulting in the secretion of the delicate spore-shells at the surfaces of spheres of influence which radiate from the nuclei. The nuclei of the multitudinous spores are thus the visible signs of those invisible and almost mathematical points of origin where the mysterious powers of plasm come into action. In the balancing of the plasm settling to rest, these points, in virtue of their mutually repellent radio-activities,* distribute themselves equally throughout the substance ; the spore-walls are then deposited, separating each sphere from those adjacent ; a drying and shrinking process proceeds, by which isolation is completed. and the corporate life of the plasmodium passes into the individual lives of the swarm-spores.

In summing up the significance of these various phases, we can only conclude that, notwithstanding their singular transformations, the Mycetozoa are among the least complex of living organisms. Perhaps it would be better to say they consist of the simplest living matter. A substance which, in watery conditions, so readily coalesces as the swarm-spores do—which coheres so long as it remains moist and impure, as in the plasmodium stage, but which, in its purified and balanced condition, falls wholly into spores—can only be regarded as having a very feeble organisation indeed. This tendency to break up and recombine, which is the double aspect of that inherent weakness of the plasm, is obviously the orbit in which the principal phases of the Mycetozoa revolve, influenced by variations of environment. This can be fairly affirmed, without forgetting for a moment that many details of the vital processes are at present inexplicable.

In the realm of physics we are coming to understand that all matter contains large stores of energy locked up in every smallest particle ; but we also learn that some of this imprisoned energy is constantly escaping. In the case of inanimate matter the energy disperses in all directions, and is lost in the universal flux of things ; but with living matter it is not so. The escaping energy of the food-substances absorbed is caught and controlled in the colloidal meshes of the plasm, and the activities

---

* The term "radio-activity" is used by the author to denote "activities radiating from centres," and not in the restricted sense as used in physical science.

set up at the points indicated by the nuclei are regulated for the benefit of the organism. Exactly how the energy is regulated by the specific texture of the plasm of each living thing, for its own particular ends, science cannot yet tell us; and the task of investigation is one of the most difficult. But that the living substance of which all organisms consist owes its strange powers to radio-active* energy continually liberated within it, at innumerable and almost mathematical points, closely distributed throughout its whole mass, appears to be beyond doubt; and of this the Mycetozoa, in the act of spore-formation, furnish a luminous example for which we may be grateful. For, lowly as they are, we cannot regard the Mycetozoa as otherwise than in essential accord with the constitution of the whole teeming world of organic life, with all its wonderful developments in the direction of the higher organisms which have left the primitive Mycetozoa so far behind.

---

* See footnote on previous page.

ON A NEW CLASSIFICATION OF THE BDELLOID ROTIFERA.

By David Bryce.

(*Read June 28th*, 1910.)

It has long been felt by those who are interested in the Bdelloid Rotifera that a revision of the classification of this group would considerably facilitate further investigation into a comparatively little-known corner of the animal kingdom. During the last eighteen years the number of known species has more than doubled, the great majority of the new forms being additions to the two genera *Philodina* and *Callidina*, which have consequently become overcrowded, unwieldy, and unsatisfactory. Besides this, a more intimate acquaintance with the diversities of structure and of habit of a greatly extended array of species has proved that not only are the old generic definitions inadequate, but that they are also unreliable, and should no longer be accepted.

The object of this paper is to place the classification of the Bdelloida on a more satisfactory basis, and it is hoped that the arrangement now put forward will provide a sound foundation, or, at the least, a new starting-point for future work, and that the lines on which it is framed will prove to be reliable and true to the natural relationships of the species with which it deals.

From the point of view of classification the Bdelloid Rotifera have already experienced a somewhat complicated career. Their history as a recognised group of allied species seems to have begun in 1830, when Ehrenberg published his first Classified List of Micro-organisms (**2**), wherein he introduced the family *Zygotrocha*, comprising all Rotifera with a ciliary wreath of two similar parts. So far as regards the Bdelloida this earliest classification may be summarised thus:

Family Zygotrocha.

Rotifera with corona of two similar parts ("ciliorum coronulis binis"),

Loricate	Section *Brachionaea*.
Illoricate	Section *Philodinaea*.

Section Philodinaea.

Without eyes	Gen. *Callidina.*
With two eyes.	
Eyes frontal:	
Foot thrice furcate ("cauda ter furcata")	Gen. *Rotifer.*
Foot ending in two spurs and three toes ("caudae quinque apicibus")	Gen. *Actinurus.*
Eyes dorsal:	
Foot simply furcate ("cauda simpliciter furcata")	Gen. *Monolabis.*
Foot thrice furcate ("cauda ter furcata")	Gen. *Philodina.*

In the following year, 1831, Ehrenberg published a more comprehensive arrangement (**3**), in which the *Philodinaea* were advanced to the rank of a family, and this position was again assigned to them in his great work of 1838 (**4**), based upon his third and best-known system of classification. In these later schemes the two genera *Typhlina* and *Hydrias* were added to the Family with the following characters:

Without rostrum or spurs:	
Trochal discs on pedicels	Gen. *Hydrias.*
Trochal discs without pedicels	Gen. *Typhlina.*

It has not yet been found possible to recognise any of the species assigned to the genera *Monolabis*, *Hydrias*, and *Typhlina*, and these genera have not been accepted by later writers, who believe them to have been founded on imperfect observations of animals which, if again seen, have been referred to other groups of the Rotifera. The four genera, *Callidina*, *Philodina*, *Rotifer*, and *Actinurus*, have fortunately proved to be recognisable, and the majority of the species, which have been discovered since 1838, have been assigned to one or other of them.

As in the classification of 1830, so in his later schemes, Ehrenberg distinguished the four genera last named principally upon characters afforded by the presence or absence of eyes, and, when present, by their position, either in the front of the head or in the neck. As a quite subsidiary character, to distinguish *Rotifer* from *Actinurus*, and *Philodina* from *Monolabis*, he made use of the number of spurs and of toes on the foot. It has been pointed out by Murray in a recent paper (**63**) that the distinction made was inaccurate as between *Rotifer* and *Actinurus,* since the foot is not thrice furcate in the species assigned to *Rotifer*. But if inaccurate in that case, the phrase "cauda ter furcata" is correct with regard to the genus *Philodina*, and clearly indicates the two spurs, the two dorsal toes, and the two terminal toes possessed by all but one of the species which were described by Ehrenberg as members of that genus.

In 1884 Hudson (**17**) recognised the distinctive character of the manner of creeping peculiar to the group, and proposed that the several genera should form a separate order, that of the BDELLOIDA, or Leech-like Creepers, and this proposal was further established by its adoption in *The Rotifera*, published by him in 1886 in collaboration with Gosse (**19**). In this work the new family *Adinetadae* and the new genus *Adineta* were created for the reception of a species which differed markedly in the type of the corona from all others of the group included by them at that time. The four recognisable genera of Ehrenberg were placed in the new family *Philodinadae*, and were distinguished as before by the presence and position of the eyes.

Earlier in the same year, 1886, the importance given by Ehrenberg to the eyes in the generic distinction of the *Philodinaea* had been challenged by Milne (**18**), who proposed to arrange the various species into genera either new or redefined, and to discard altogether all generic characters relating in any way to the eyes. He claimed for his scheme that it did not dissociate manifestly similar forms, at least as regards some nineteen species examined by him. His most valuable suggestion in this paper was that the genus *Philodina* should be distinguished by the possession of four toes, thus giving first place to the character which Ehrenberg had indicated in 1830 in the phrase "cauda ter furcata."

In 1888 Milne (**23**) adduced fresh instances in support of his previous contention, and proposed further that the genus *Rotifer* should be distinguished by the character "viviparous."

Another important advance was made in 1889, when Plate (**27**) pointed out that the *Bdelloida* shared with the *Seisonidae* the peculiarity of having two ovaries, whereas all other Rotifera have one only. He proposed therefore to divide the class ROTIFERA into two sub-classes, the DIGONONTA (or two-ovaried), comprising the Bdelloida and the Seisonidae, and the MONOGONONTA (or one-ovaried), including all other Rotifera.

In a useful monograph on the *Philodinaea*, published in 1893, Janson (**38**) discussed at some length the views and suggestions of earlier writers and, in particular, those of Hudson and Gosse, and of Milne. On the one hand, he criticised the creation by the former authors of the family of the *Adinetadae*. On the other, he admitted the contention of Milne that under the definition of Ehrenberg many eyeless species would be classed as *Callidinae*, although in respect of their structure they should clearly be regarded as belonging to the genus *Rotifer*. Nevertheless he hesitated to accept the genera proposed by Milne, and preferred for the time to abide by the Ehrenbergian family of *Philodinaea*, which in his view covered all the various genera. He made the one correction of transferring to the genus *Rotifer* the two species which had been assigned to *Actinurus*, recent discoveries having shown the differences between these two genera to be less definite than had previously appeared.

In an important treatise published in 1899 Wesenberg Lund (**50**) dealt in great detail with the wide question of the relationship to each other of all the various groups of the Rotifera, and, in conclusion, put forward a new classification based largely upon results afforded by his own investigations. At the outset he followed Plate in dividing the class ROTIFERA into the sub-classes MONOGONONTA and DIGONONTA according to the number of ovaries possessed by each species. So far as regards the MONOGONONTA, the subsequent grouping of the families and genera was carried out on principles essentially different from those of Hudson and Gosse. The DIGONONTA, on the other hand, were little affected by the investigations of the author, according to whom this sub-class included the two orders BDELLOIDA and SEISONACEA, the latter created to receive the family of the Seisonidae. While accepting from Hudson the order of the BDELLOIDA, Wesenberg Lund followed Janson in placing all the Bdelloid genera in one family, *Philodinidae*, and in rejecting the genus *Actinurus*. The family *Philodinidae* of Wesenberg Lund would thus be equivalent to Ehrenberg's family *Philodinaea*, and according to the author included the five genera *Rotifer*, *Philodina*, *Callidina*, *Discopus*, and *Adineta*.

In 1905 James Murray (**55**) announced the discovery of the curious Bdelloid, *Microdina paradoxa*, for which he created the new family *Microdinadae*. This and numerous other discoveries of Bdelloid forms hitherto unknown, and in all cases communicated to me before publication, led naturally to the discussion in our correspondence of the demerits of the current classification of the group. The arrangement of the genera and species now advanced is in great measure the outcome of that discussion. To some extent the lines on which it is mainly framed have been indicated by my correspondent in recent papers, notably in (**56**) "The Bdelloid Rotifera of the Forth Area" (1905) and in (**63**) "*Philodina macrostyla* and its Allies" (1908).

In the former of these he provisionally redefined the genera *Philodina*, *Callidina*, and *Rotifer* as follows:

PHILODINA.—Having four toes and a corona consisting mainly of a pair of wheel-like ciliated discs.

A. Eyes present; oviparous.
B. Eyes absent; oviparous.
C. Viviparous; eyes present or absent.

CALLIDINA.—Having three toes or a perforate disc formed by a union of the toes; oviparous; eyes present or absent.

A. Food moulded into pellets.
B. Toes bearing a number of cup-like suckers, or united to form a broad disc.
C. Toes three; distinct, food not moulded into pellets.

ROTIFER.—Viviparous; toes three.

In the latter paper he discusses exclusively the genus *Philodina*, which he redefines as distinguished by:

Four toes, eyes cervical or none;

and subdivides into five groups of species:

I. Oviparous.
II. Semiloricated.
III. Parasitic.
IV. Short-spurred.
V. Viviparous.

During the period covered by the foregoing retrospect the number of species known to belong to the Bdelloid group has very considerably increased. In Ehrenberg's classification of

1830 there are enumerated nine species, of which one, at least, has not been recognised since. The present arrangement deals with a total of 105 species considered to be capable of recognition, in addition to which some 49 species have been placed in a separate list as either insufficiently described or otherwise invalid.

These "doubtful" species are not necessarily hopeless. Before the lists are again revised, further observations may well have provided sufficient reason for reinstating some of them among the species considered good.

I do not desire to offer any remarks upon the position to be assigned to the BDELLOIDA among other Rotifera. Although it would now seem that the BDELLOIDA do not stand quite so far from the others as was formerly believed, yet the interval which separates them appears still to be a wide one. It is sufficient to accept the position assigned to them by Plate and Wesenberg Lund and to regard them as an order of the sub-class DIGONONTA, distinguished from the SEISONACEA by their ramate jaws, their more or less effective rostrum, the telescopic retractability of their distal segments, and their contractile cloaca.

To the order of the BDELLOIDA I assign the three families, PHILODINIDAE, ADINETIDAE, and MICRODINIDAE. In my opinion both Janson and Wesenberg Lund, in rejecting the family *Adinetadae* of Hudson and Gosse, have failed to appreciate the physiological difference, which is so intimately connected with the structural distinctions between the *Adinetidae* and the *Philodinidae*. The former family, while possessing certain minor capacities which are not shared with the latter, falls nevertheless far behind in structural development and in functional equipment. It need only be pointed out that the *Adinetidae* are practically unable to swim and that their locomotive abilities are limited to creeping about by means of their corona, aided by the foot. The *Philodinidae*, on the other hand, can all swim in a more or less vigorous manner. They can also creep about in leech-like fashion by the alternate use of the tip of the rostrum and of the foot. But what in my view is most important, is that this creeping about is not in any degree dependent upon the use of the corona. That delicate organ is for the time hidden away within the mouth and so secured from possible injury. This power of withdrawal of the corona without absolute prejudice to the power of locomotion is associated with and consequent upon a whole series of structural developments, and distinguishes the *Philodinidae*, not only from the *Adinetidae*, but from all other members of the class ROTIFERA.

The *Microdinidae* are even more feebly equipped than the *Adinetidae*. The corona is practically absent, and the animals can only creep about in a slow and clumsy manner by means of the rostrum and foot. They have some little compensation in being able to partly protrude their jaws from the buccal opening. It is hoped that the discovery of forms allied to the single species yet known will provide further indications of its affinities with other Bdelloida, but meanwhile I agree with Murray that *M. paradoxa* is well placed in a genus and a family of its own.

The recently discovered and very remarkable species to which De Beauchamp (**65**) has given the specific name "*intermedia*" shows a distinct advance in the direction of *Microdina* in the structure of the mastax, in its adaptation to prehensory movements, and in the absence of any throat. But it possesses a fully developed rostrum, and a corona which, although differing in important details from that which is typical of the *Philodinidae*, is nevertheless retractile at will within the mouth, and the species therefore comes well within the limits of that family as indicated in the definition following.

The family MICRODINIDAE, distinguished by the presence of a rostrum and the absence of a corona, consists therefore of the single genus MICRODINA, represented by one species.

The family ADINETIDAE, having an imperfect or retrograde rostrum, and a corona which cannot be retracted within the mouth, comprises the two genera ADINETA and BRADYSCELA, the latter created to receive the species "*clauda*," which differs very notably from the *Adineta* type in the structure of the foot.

The family of the PHILODINIDAE includes all Bdelloids with well-developed rostrum and corona, the latter always capable of retraction within the mouth. With the exception of the four forms placed in the new genera CERATOTROCHA, SCEPANOTROCHA, and ABROCHTHA, the numerous species conform in most respects very closely to one structural plan.

Of the few deviations from uniformity of plan, I regard as of great importance that which is found in the structure of the stomach of certain species. Although not hitherto employed or suggested as a means of generic distinction, it has not quite escaped observation, as may be judged from Ehrenberg's figure of the stomach of *Philodina collaris* (**4**), and from his description of that organ both in that species and in his *Callidina redivira.* Gosse, in his turn, observed some peculiarities about the stomach of *Callidina bidens* (**19**) which he did not rightly interpret. Lastly, Milne (**18**) in his descriptions of species discovered by him drew attention in several cases to the remarkable habit of moulding the food into pellets, which is universal amongst species whose stomach-structure deviates from the customary form in the manner now to be pointed out.

Briefly stated, the distinction made consists in the proportion of the cavity of the inner or lining membrane of the stomach to the cavity of the outer or enclosing membrane, and it is constantly associated with a difference in the method of digestion and with other structural differences, which, if not of great value in themselves, indicate clearly enough that the difference in the stomach-structure is one that goes a long way back in the evolution of the Bdelloida. Making use of this distinction I have divided the genera of the PHILODINIDAE into two Sections:

A. Lumen of stomach relatively wide, or bag-like; food usually in pellets; upper lip usually entire; oviparous.

B. Lumen of stomach relatively narrow, or tube-like; food particles free, never agglutinated into pellets; upper lip usually bilobed or divided; oviparous or viviparous.

In the genera of Section B the inner tube is very much narrower than the outer, the interspace being occupied by a finely granulated digestive fluid, having a frequent admixture of fat-particles. In the genera of Section A the inner tube is almost as wide as the outer, and the granulated fluid is usually scanty or apparently absent. Again, when the lumen is tube-like one frequently finds ciliary action visible either in the stomach or in the intestine. In my experience such action is never seen when the lumen is relatively wide. The moulding of the food into pellets, which is universal among the species of Section A, has never been detected in any species with a relatively narrow lumen.

It is not to be expected that among so many species all should conform with equal fidelity to the distinction made between the relatively narrow and the relatively wide lumen of the stomach. Notably in the genus *Rotifer* many species have the lumen tube-like, but the outer membrane is not conspicuously of much greater capacity.

To Section A belong the three new genera, HABROTROCHA, CERATOTROCHA, and SCEPANOTROCHA. In the first-named the corona conforms with relatively minor modifications to the type usual in the family. In CERATOTROCHA that portion of the skin whch supports the upper lip and the lateral cushions of the mouth is produced into two horn-like processes upon whose lower or ventral surface are inset the ciliated discs, the pedicels which usually support the latter being either rudimentary or absent. In SCEPANOTROCHA the upper lip itself is modified into a membranous hood-like expansion larger than the corona, which it completely covers (save the extremities of the cilia), and which it dorsally screens.

These three genera claim about one-fourth of the species of the PHILODINIDAE. In my opinion they are representative of an earlier stage in the development of the typical Philodine, the genera of Section B representing, broadly speaking, a *distinct advance in development, shown by their greater average size, the greater proportional development of the corona, especially of the trochal discs, and their greater activity, mobility, and boldness.*

The genera of Section B, comprising all PHILODINIDAE in which the lumen is tube-like, divide naturally into three Subsections:

I. With four toes (two dorsal, two terminal).
II. With three toes (one dorsal, two terminal).
III. With toes bearing a number of cup-like suckers, or united to form a broad disc, or twin discs.

Subsection I., with four toes (the dorsal pair usually somewhat distant from the terminal).—In this subsection the remarkable foot of the Bdelloid rotifer attains its highest development. The comparatively wide separation of the two pairs of toes, the independent action of each pair, their consequent control by different muscles and nerves, the rapidity and certainty of their affixment, indicate greater specialisation than is exhibited by any other groups, however closely approached by individual forms. In the same way, the four-toed species surpass their relatives in the development of the corona. The average width of the trochal discs, in some species extremely ample, and its proportion to the body-length are much in excess of those seen in other

Philodinidae. In my opinion these details form good indices to the functional perfection of the food-collecting organ.

The four-toed species constitute about one-third of the PHILODINIDAE in the present list. I have divided them among five genera, of which three correspond to groups suggested by Murray as already quoted, viz. the "parasitic," the "viviparous and long-spurred," and the "semi-loricate" groups. For these I propose the new genera EMBATA, DISSOTROCHA, and PLEURETRA respectively.

For the present I hesitate to separate the "short-spurred species" (of Murray) from the "oviparous." Together they form a fairly compact genus, which includes nearly all the species assigned by Ehrenberg to the genus PHILODINA, and for which I therefore retain that generic name. In these four genera the corona is always in close conformity with the family type, and in every case there is a distinct throat or passage to the mastax. In the recently described (*P.*) *intermedia*, de Beauchamp, the corona differs from the type in several details (most notably in the partial absence of the cingulum or secondary wreath), and there is practically no throat, the mastax being placed so closely below the mouth that the jaws themselves can be employed in seizing the food. For generic distinction the latter character appears to me to be the most suitable, and I propose therefore to refer to it in creating for this remarkable species the new genus ABROCHTHA.

Subsection II., with three toes (the dorsal toe usually close to the terminal pair).—The species with three more or less well-developed toes are divided according to their customary course of reproduction. For those which are viviparous I have retained the generic name ROTIFER as suggested by Milne (**23**). This emendation of the distinctive character makes little change in the constituent species. With the exception of the discordant form "*roeperi*," now transferred to the genus HABROTROCHA, all the species with rostral eyes are viviparous, and therefore remain in the genus with which they have been hitherto associated, whilst to their number is added the blind but closely related species "*longirostris*" Janson, and "*magnicalcarata*" Parsons. For those other three-toed species which are oviparous I retain the generic name CALLIDINA, not because the genus as now presented contains any of the eight species described by Ehrenberg, who created the genus (for the opposite is the case), but because the majority of the species now assigned to it have of late years seemed to me to represent the central group of the very heterogeneous crowd of forms which the too elementary definition of "no eyes" has caused to be associated with this name. For reasons which will be later explained I am far from satisfied that the identity of Ehrenberg's *Callidina elegans*, the species for which he created the genus *Callidina*, has been rightly determined by any of the authors who have hitherto accepted it, nor, although particularly anxious to establish as many as possible of the old but too scantily described forms, have I myself succeeded in finding it. As to his next described species, *Callidina rediviva*, which would seem to be a pellet-making form, I am in the same position. Of six other species described by him after a long interval, three are now recognisable, but belong to two very distinct groups, (*C.*) *alpium* having four toes, and (*C.*) *scarlatina* and (*C.*) *tetraodon* having the foot ending in a sucker-like disc. Under these circumstances I have felt myself at liberty to employ the familiar name for those species which remain in the old genus after relieving it of the most aberrant forms. The new definition is perhaps somewhat too comprehensive still. The genus includes three rather distinct groups of species which may be characterised respectively as :

1. Rough-skinned.
2. Smooth-skinned, short-footed, non-parasitic.
3. Smooth-skinned, long-footed, and parasitic.

For the rough-skinned and the parasitic groups I think it will ultimately be desirable to provide separate genera. The second group of smooth-skinned, short-footed, non-parasitic forms I regard as generally representing the type of the genus CALLIDINA.

Subsection III., with toes bearing cup-like suckers or united to form a broad disc or twin discs.—Although the species included in this subsection are relatively few in number, certain of them have been more exhaustively studied than all the other Bdelloida together. The majority are large forms, possessed of well-developed coronae, and they usually inhabit ground-mosses and liverworts of various kinds. But besides the moss-dwelling forms there are two species which are parasitic in habit and very distinct in some structural details, viz. *Discopus synaptae* Zelinka, and *Anomopus telphusae* Piovanelli. The genera DISCOPUS and ANOMOPUS are distinguished from each other by the arrangement of the foot-glands, which in DISCOPUS are placed in transverse series, but in ANOMOPUS in longitudinal series as in all other Bdelloida. For the moss-dwelling species I propose the new genus MNIOBIA, distinguishing it from DISCOPUS by the longitudinal arrangement of the foot-glands, and from the long-footed ANOMOPUS by the relatively short foot.

The order in which these families and genera should be placed is more than difficult to determine. If, as I think is the case, the pellet-making species are nearest to the primitive Bdelloid type, the genera HABROTROCHA, SCEPANOTROCHA, and CERATOTROCHA may be taken as representing the central line of growth from which at one period or another other groups have branched off, in most cases to subdivide again. If, however, the functional development of the various genera—that is to say, their capacities for gathering food, for locomotion, their general activity and endurance—be considered, then I think the genus PHILODINA should stand first, yet be closely approached by ROTIFER and CALLIDINA, while at the foot of the list should appear MICRODINA and BRADYSCELA, with CERATOTROCHA but little above them.

But it is impossible in the mere sequence of genera and species to give any adequate idea of both the relationships and the comparative development of the several groups which the genera are intended to represent. For the sequence of genera which after various rearrangements I have finally adopted I make no claim save that of convenience.

The new genus SCEPANOTROCHA is represented only by two species new to science, and descriptions of these accompanied by figures follow after the general classification.

The list of species regarded as insufficiently described or otherwise invalid is supplemented by remarks on certain of the species included therein.

I conclude this paper with a list of works dealing with earlier classifications of the BDELLOIDA, or containing original or supplementary descriptions of species, so far as I am acquainted with them. Throughout the text reference is made to these works by numbers enclosed in brackets after the author's name.

(In the event of any described species or work having been omitted from the respective lists I shall be grateful if the fact be made known to me.)

SYNOPSIS OF THE FAMILIES, GENERA, AND SPECIES.

ORDER BDELLOIDA
- Fam. ADINETIDAE
  - Gen BRADYSCELA gen. nov.
  - ,, ADINETA Hudson and Gosse.
- ,, PHILODINIDAE
  - A
    - ,, CERATOTROCHA gen. nov.
    - ,, SCEPANOTROCHA gen. nov.
    - ,, HABROTROCHA gen. nov.
  - B
    - ,, CALLIDINA Ehr.
    - ,, ROTIFER Schrank.
    - ,, DISSOTROCHA gen. nov.
    - ,, PLEURETRA gen. nov.
    - ,, EMBATA gen. nov.
    - ,, PHILODINA Ehr.
    - ,, ABROCHTHA gen. nov.
    - ,, DISCOPUS Zel.
    - ,, ANOMOPUS Piov.
    - ,, MNIOBIA gen. nov.
- ,, MICRODINIDAE
  - ,, MICRODINA Murray.

BDELLOIDA,

An Order of the Sub-class DIGONONTA Plate **27**
(Rotifera with two Ovaries).

ROTIFERA, with spindle-shaped, maggot-like bodies of numerous segments, those of the anterior and posterior extremities telescopically retractile within those of the central body; having ramate jaws, a more or less developed rostrum, and a contractile cloaca. Males unknown.

I. FAMILY **Adinetidae.**

Bdelloids, with usually imperfect non-revertile rostrum. Corona consisting of a prone surface clothed with short cilia (which create no vortices), and non-retractile within mouth. Two genera.

Bradyscela gen. nov.

Foot stout, with three toes, spurs modified or absent.

B. clauda (Bryce) **36**.

Adineta Hudson and Gosse **19.**

Foot slender, with two spurs and three toes.

A. vaga (Davis) **15.**
A. oculata (Milne) **18.**
A. longicornis Murray **59.**
A. grandis Murray **66.**
A. tuberculosa Janson **38.**
A. barbata Janson **38.**
A. gracilis Janson **38.**

II. FAMILY **Philodinidae.**

Bdelloids with fully developed rostrum, usually revertile. Corona of two functionally distinct wreaths of cilia; the trochus, dorsally and ventrally interrupted, passing nearly round the peripheries of two elevated discs, and creating twin vortices; the cingulum, dorsally interrupted, passing from behind the pedicels round their bases, and thence round inferior margin of mouth. Corona retractile within mouth.

Thirteen genera.

A. Lumen of stomach relatively wide or bag-like. Food usually agglutinated into pellets. Upper lip usually undivided. Oviparous.

a. Pedicels rudimentary or absent.

Ceratotrocha gen. nov.

Trochal discs inset between or beneath two fleshy processes resembling horns.

C. cornigera (Bryce) **37.**

Scepanotrocha gen. nov.

Trochal discs inset beneath wide hood-like membranous expansion of upper lip.

S. rubra sp. nov.
S. corniculata sp. nov.

b. Pedicels more or less developed.

Habrotrocha gen. nov.

Corona of family type without horn-like processes or hood-like expansions.

- *H. angusticollis* (Murray) **55.**
  - var. *attenuata* (Murray) **59.**
- *H. longiceps* (Murray) **58.**
- *H. perforata* (Murray) **59.**
  - var. *americana* (Murray) **60.**
- *H. pusilla* (Bryce) **37.**
  - var. *textrix* (Bryce) **44.**
- *H. collaris* (Ehrenberg) **3, 4.**
- *H. eremita* (Bryce) **41.**
- *H. elegans* (Milne) **18.**
- *H. annulata* (Murray) **55.**
- *H. leitgebii* (Zelinka) **20.**
- *H. roeperi* (Milne) **23.**
- *H. reclusa* (Milne) **23.**
- *H. bidens* (Gosse) **8, 19.**
- *H. tripus* (Murray) **60.**
- *H. tridens* (Milne) **18.**
- *H. lata* (Bryce) **33.**
- *H. angularis* (Murray) **66.**
- *H. pulchra* (Murray) **55.**
- *H. constricta* (Dujardin) **6.**
- *H. microcephala* (Murray) **56.**
- *H. minuta* (Murray) **61.**
- *H. aspera* (Bryce) **33.**
- *H. crenata* (Murray) **55.**
  - var. *nodosa* (Murray) **59.**

B. Lumen of stomach relatively narrow or tube-like. Food never agglutinated into pellets. Upper lip usually bilobed or divided. Oviparous or viviparous.

a. Foot ending in three toes.

Callidina Ehrenberg **2.**

Oviparous.

- *C. aculeata* (Milne) **18.**
- *C. fusca* Bryce **41.**
- *C. muricata* Murray **55.**
- *C. multispinosa* (Thompson) **34.**
  - var. *brevispinosa* Murray **64.**
  - var. *crassispinosa* Murray **60.**
  - var. *zickendrahti* Richters **67.**
- *C. pinnigera* Murray **64.**
- *C. papillosa* (Thompson) **34.**
- *C. quadricornifera* (Milne) **18.**
- *C. vesicularis* Murray **57.**
- *C. formosa* Murray **59.**
- *C. habita* Bryce **41.**
  - var. *bullata* Murray **58.**
- *C. angusta* Bryce **41.**
- *C. crucicornis* Murray **55.**
- *C. natans* Murray **58.**
- *C. plicata* Bryce **33.**
  - var. *hirundinella* Murray **61.**
- *C. musculosa* (Milne) **18.**
- *C. ehrenbergii* Janson **38.**
- *C. cancrophila* Piovanelli **53.**
- *C. branchicola* Němec **43.**
- *C. speciosa* Murray **60.**

Rotifer Schrank **1**

Viviparous.

R. longirostris (Janson) **38.**
  var. *fimbriata* Murray **59.**
  var. *bitorquata* Murray **64.**
R. tardigradus Ehrenberg **2, 3.**
R. elongatus Weber **26.**
R. trisecatus Weber **26.**
R. spicatus Murray **51.**
R. mento Anderson **30.**
R. citrinus Ehrenberg **4.**
R. vulgaris Schrank **1.**
R. macrurus Schrank **1.**
R. ovatus (Anderson) **30.**
R. neptunius Milne **18.**
R. actinurus Janson **38**
(= *Actin. neptunius* Ehr. **2, 3**).
R. magnicalcarata (Parsons) **32**
(= ? *Callidina socialis* Janson **38**).

b. Foot ending in four toes.
* With distinct throat.
† Skin coarse and leathery.

Dissotrocha gen. nov.

Viviparous; abdominal transverse skinfolds few and corresponding to segment boundaries.

D. spinosa (Bryce) **33.**
D. aculeata (Ehrenberg) **2, 3.**
D. macrostyla (Ehrenberg) **4**

Pleuretra gen. nov.

Oviparous; abdominal transverse skinfolds numerous and not corresponding to segment boundaries.

P. alpium (Ehrenberg) **10.**
P. humerosa (Murray) **55.**
P. brycei (Weber) **47.**

†† Skin usually smooth and flexible.

Embata gen. nov.

Spurs usually long and heeled; animals mostly ectoparasitic upon water-dwelling larvae, isopods, etc.; viviparous or oviparous.

E. parasitica (Giglioli) **12.**
E. hamata (Murray) **58.**
E. laticornis (Murray) **55.**
E. laticeps (Murray) **55.**
E. commensalis (Western) **35**

Philodina Ehrenberg **2.**

Spurs usually short and without heel; animals wandering and free in habit. Mostly oviparous, rarely viviparous.

P. roseola Ehrenberg **3.**
P. erythrophthalma Ehrenberg **2.**
P. flaviceps Bryce **58.**
P. vorax (Janson) **38.**
P. citrina Ehrenberg **2, 3.**
P. acuticornis Murray **51.**
P. megalotrocha Ehrenberg **3.**
P. indica Murray **59.**
P. convergens Murray **61.**
P. brevipes Murray **51.**
P. nemoralis Bryce **54.**
P. rugosa Bryce **54.**
  var. *callosa* Bryce **54.**
  var. *coriacea* Bryce **54.**
P. plena (Bryce) **41.**
P. squamosa Murray **59.**
P. gregaria Murray **66.**
P. antarctica Murray **66.**
P. alata Murray **66.**

** Without throat.

Abrochtha gen. nov.

Gullet absent. Rami immediately below mouth-cavity and protrusible thereinto.

A. intermedia (de Beauchamp) **65.**

c. Foot ending in sucker-like disc or twin discs.

* Foot-glands in transverse series.

Discopus Zelinka **25.**

No rostral lamellae, viviparous.

D. synaptae Zelinka **25.**

** Foot-glands in longitudinal series.

Anomopus Piovanelli **53**

Foot elongate.

A. telphusae Piovanelli **53.**

Mniobia gen. nov.

Foot short.

M. magna (Plate) **27.**
M. russeola (Zelinka) **29.**
M. symbiotica (Zelinka) **20.**
M. scarlatina (Ehrenberg) **10.**
M. tetraodon (Ehrenberg) **7.**
M. armata (Murray) **55.**
M. incrassata (Murray) **55.**
M. circinata (Murray) **61.**

III. FAMILY **Microdinidae** Murray **55**

Bdelloids with fully developed but non-revertile rostrum. Corona absent or represented by few cilia about the mouth.

1 genus.

Microdina Murray **55**

Toes four.

M. paradoxa Murray **55**

Scepanotrocha rubra sp. nov. (Pl. 2, Fig. 1.)

SPECIFIC CHARACTERS: Hood-like expansion slightly convex, without median notch or lateral projections; hinder margin excised, merging into upper lip. Rami with six or seven fine teeth. Spurs short blunt-looking cones, with small interspace.

When creeping about, this species has some resemblance to young examples of *Habrotrocha constricta* (Duj.), especially if colourless, yet may be distinguished by its more slender head and general outline, its more uniform width, and the blunt-looking, less divergent spurs. When newly obtained from moss-washings it is exceedingly restless and marches about vigorously. After a few days' isolation it becomes very quiet and displays its corona quite freely. While feeding it remains affixed with the foot, and does not drift about, nor does it readily move away.

The outline of the "hood" is best seen in young individuals, where it is distinctly broader than the corona, having a breadth of about 24 μ, a depth of about 9 μ. The lateral margins are rounded off and the anterior is really slightly curved, but is frequently sufficiently depressed to give the central portion a flat outline. Posteriorly the "hood" merges into the upper lip, but I have thought that I could now and again distinguish a faint but boldly curved line marking the actual transition. Below the "hood," the trochal discs appear to occupy the normal position, having their planes about transverse to the body-axis, but the cilia on the dorsal portions of the discs are comparatively feeble, and the "cog-wheel" appearance is only presented by the cilia on the ventral portions. The short pedicels are approximate but distinct. The "cheeks," or lateral cushions of the mouth, are thickened, externally and ventrally prominent, and somewhat decurrent, so that in dorsal view they are partially visible to right and left of the head. The brain is moderately remote from the antenna, which in recent examples seems to be short, but was perhaps not fully protruded, as early notes describe it as long. It is, however, by no means infrequent among Bdelloids to keep the antenna partially invaginated. In the feeding position the lumbar segments show dorsally the two prominent longitudinal skinfolds familiar in some other species but not universal, and which I propose to distinguish as "the lumbar plicae." The mastax is rather small; the rami about 13 μ long, each with six or seven very fine teeth. In most examples the digestive fluid is distinctly tinted, usually reddish pink, occasionally pale brown. In the act of creeping the foot is distinctly shown. It consists of three segments, and the spurs are short cones with an unusually blunt appearance in dorsal view.

My largest examples measured about 220 μ when fully extended, about 170 μ when feeding.

This interesting species has been known to me, albeit imperfectly, for many years past. I have notes of its occurrence in sphagnum from Epping Forest, Sandown, I.W., Callander, Pitlochry, and Stuttgart. Some months ago I found several examples in sphagnum kindly sent to me by Dr. V. A. Latham, of Chicago, and these have enabled me to improve my acquaintance with its peculiarities. I have never found it in other mosses, and look upon it as almost as distinctively a sphagnum form as is *Habrotrocha roeperi* (Milne).

Scepanotrocha corniculata sp. nov. (Pl. 2, Fig. 2)

SPECIFIC CHARACTERS: Membranous hood-like expansion, having anterior median notch, two small lateral processes, and a straight posterior margin.

From ground-moss collected for me at Bournemouth early in 1909 I obtained a single specimen of this curious form, whose striking divergence from the customary type I did not detect until, some weeks after its isolation, I first saw it feeding. The membranous expansion (seemingly of the upper lip) was perfectly transparent, and the position of the trochal discs upon the ventral side could be defined, although I could not see whether they were quite prone or somewhat obliquely placed.

In dorsal view the cilia of the discs were partially visible beyond the frontal margin, and appeared as though flanked by longer bristle-like setae (?), whose nature I was unable to determine, although I supposed them to be possibly homologous with the trochal setae-pencils possessed by many Philodinidae.

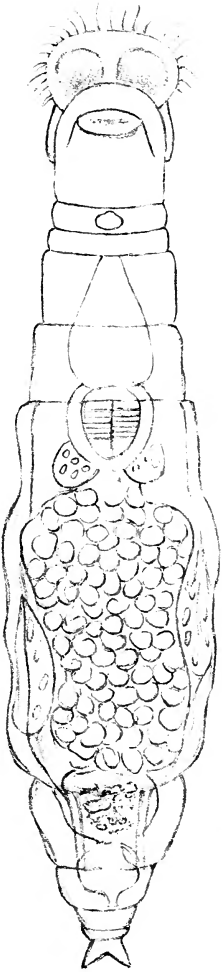
This original example had some difficulty in extending and using its foot, which I never saw protruded or affixed. Thus when extended the animal was never still, either sprawling about as it tried to creep, or when the corona was displayed being driven slowly along by the ventrally placed cilia. I failed therefore to ascertain the number of teeth, but thought that each ramus had three or four. When the corona was withdrawn, and with it the distinctive "hood," the rotifer did not present any obvious peculiarity save that the head seemed somewhat long and the rostral lamellae rather large and prominent. The anterior margin of the "hood" had a central angular depression, from which it curved outwards to right and left till it arrived at the lateral processes, which were somewhat pointed and ventrally deflexed. Their tips were about 35 μ apart. Behind them the "hood" seemed to be abruptly truncate, the hinder edge forming a straight line, behind which could be seen the reverted rostrum.

A second example was hatched from an egg produced by the original individual. In the young specimen, which did not long survive, the points of the "hood" had a rather backward direction. The foot was normally protruded and occasionally affixed, but usually the young rotifer swam slowly along like its parent. The foot seemed to have three segments: the first rather long and dorsally swollen; the second small, with short, cone-like spurs, about 6 μ long, and without interspace; the post-oral segment was laterally thickened, and carried a rather short antenna. The stomach contained distinct food-pellets.

The length of the adult example was estimated as about 205 μ.

Description of Plate 2.

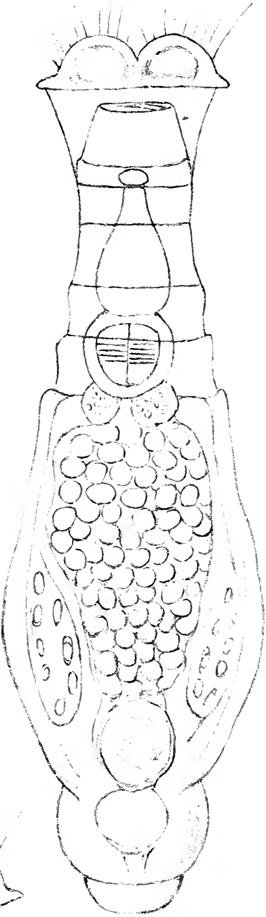
Fig. 1. *Scepanotrocha rubra* sp. nov., dorsal view.
„ 2. „ *corniculata* sp. nov., dorsal view.
b. Corona from ventral side. *c.* Foot.
d. Dorsal antenna.



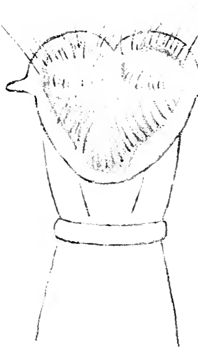
1.

2 c.

2 d.



2.



2 b.

D. Bryce, del. A. H. Searle lith.

Scepanotrocha gen. et sp. nov.

List of Species Omitted from Classification as Insufficiently Described or Otherwise Invalid. With Remarks.

Actinurus neptunius Ehr. **2** & **3** (= *Rotifer actinurus* Janson).
Adineta allaudi Certes **70** (= *A. oculata* (Milne) **18**).
Callidina elegans Ehr. **2** & **3**.
,, *rediviva* Ehr. **45** & **7**.
,, *triodon* Ehr. **7**.
,, *hexaodon* Ehr. **7**.
,, *oktodon* Ehr. **7**.
,, *pigra* Gosse **21**.
,, *bihamata* Gosse **19**.
,, *socialis* Kellicott **24**.
,, *sordida* Western **35** (= *Rotifer longirostris* Janson).
,, *laevis* Bergendal **31**.
,, *tentaculata* Ber. **31**.
,, *lutea* Zelinka **29**.
,, *mülleri* Zel. **29**.
,, *holzingeri* Zel. **29**.
,, *lejeuniae* Zel. **29**.
,, *venusta* Bryce **44** (= *Habrotrocha elegans* (Milne)).
,, *cataracta* Lord **48** (= *Pleuretra brycei* (Weber)).
,, *quadridens* Hilgendorff **46**.
,, *ornata* Murráy **51**.
Hydrias cornigera Ehr. **3**.
Monolabis conica Ehr. **2** & **3**.
,, *gracilis* Ehr. **3**.
Macrotrachela bidens Milne **18**.
Philodina hirsuta Ehr. **5**.
,, *gracilis* Schmarda **11**.
,, *calcarata* Schm. **11**.
,, *macrosipho* Schm. **11**.
,, *setifera* Schm. **11**.
,, *tuberculata* Gosse **19**.
,, *cinnabarina* Zacharias **69**.
,, *hexodonta* Bergendal **31**.
,, *microps* Gosse **22**.
,, *parasitica* Marchoux **49**.
,, *decurvicornis* Murray **51**.
,, *obesa* Murray **51**.
,, *emini* Collin **45**.
Rotifer erythraeus Ehrenberg **3**.
,, *maximus* Bartsch **14**.
,, *motacilla* Bartsch **14**.
,, *megaceros* Schmarda **11**.
,, *tardus* Ehr. **4** (= *Rotifer tardigradus* Ehr.).
,, *hapticus* Gosse **19**.
,, *phaleratus* Glascott **39**.
,, *quadrioculatus* Murray **51**.
,, *forficulatus* Barrois & Daday **42**.
,, *inflatus* Dujardin **6**.
Typhlias viridis Ehr. **3**.

1.—*Callidina elegans* has appeared so frequently, both in local lists and in more important works, as an accepted and valid species, that it is incumbent upon me to enter more fully than I should otherwise do into the reasons which force me to discredit all the identifications which I have seen of this elusive species. It has first to be noted that, although Ehrenberg mentions it both in 1830 (**2**) and in 1831 (**3**), the few particulars he gives (on the latter occasion) may be taken as superseded by those given in 1838 (**4**), since in the interval he had found the species on two occasions (but from the same locality as the original capture). Further, that his description of the genus *Callidina* was based on this one species only, as the second known to him—*Callidina rediviva*, also mentioned in the same work (**4**)—was only found about the time when the proof-sheets were already under revision. Thus the identity of *C. elegans* is to be judged not only from the specific description, but also from the description of the genus *Callidina*, wherein particulars are given which have much importance. Collating both descriptions, it is to be gathered that *C. elegans* of Ehrenberg was a blind Philodine, oviparous and spindle-shaped, having a stout ciliated rostrum and a long-extending foot with two spurs and four toes: a corona of two small discs, not mounted on pedicels; rami with many very fine teeth; stomach thread-like; antenna short; with some resemblance to *Philodina erythrophthalma*, but with spurs somewhat longer than in that species yet shorter than in *P. macrostyla*, and with very short terminal toes. Some seven figures are given to supplement this description, and are principally noteworthy for the curious presentment of the corona, which gives some ground for Milne's (**18**) interpretation of it as of the Adineta type, and which certainly gives no clear suggestion of any form of corona known to me.

The description of the stomach as thread-like ("fadenartig") in the generic description is to be understood as referring to *C. elegans*. In the description of *C. rediviva*, interpolated at the time of proof-revision, Ehrenberg notes as a conspicuous mark the breadth of the food-canal, apparently meaning the lumen of the stomach, and he speaks of the stomach-structure as resembling that of *P. collaris*. It is clear from the further details given that both *P. collaris* and *C. rediviva* had stomachs with a wide lumen, and that both were pellet-makers. That such is the case with *C. rediviva* gives the more weight to the description of the stomach in *C. elegans* as thread-like.

If one may rely on the various details given by Ehrenberg, his *C. elegans* differs in several respects from that described by

Hudson and Gosse (**19**) as his species. These authors neither confirm nor deny the accuracy of Ehrenberg's statements. Yet they state that the form recognised by them as his *C. elegans* has an antenna longer than the width of the corona, that it has three toes, that the spurs are middling, and that the foot is thick—a final detail which is important, since it contradicts the resemblance to *P. erythrophthalma*, which has a foot as long and as slender as that of *P. roseola*. That Hudson and Gosse's species had no prominent teeth does not perhaps conflict with Ehrenberg's description of the rami as having many fine teeth.

It has, however, seemed to me to be possible to recognise the animal which Hudson and Gosse had in mind. Their description of the corona is the one happy touch which indicates a species common enough in weedy pools. They say that the corona is scarcely wider than the body, the double disc being very little more than a full circle or two circles very slightly separated.

The species to which this description in my opinion applies the best has a number of fine teeth, a corona with discs whose pedicels are somewhat squat or truncate, and in these details would not appreciably conflict with Ehrenberg's description; but the foot has no resemblance to that of *P. erythrophthalma*, the spurs have a most distinctive form not suggested by either of the authors, and, above all, the species has a *wide lumen* and is distinctly a *pellet-maker*.

It is probable that the form which Janson (**38**) cursorily describes as Ehrenberg's species is identical with that of Hudson and Gosse, if one may judge from his description and figure of the spurs. He states that the foot has only three segments, that the rami have ten to eleven fine teeth, and that the antenna is somewhat large.

Ehrenberg was possibly mistaken as to the number of toes. It is known that he was inaccurate on this point with respect to the genus *Rotifer*, while correct with regard to the genus *Philodina*. But I cannot think that he would have failed to distinguish between the short stout foot of Hudson and Gosse's *C. elegans*, and the long slender foot of *P. erythrophthalma*, and that he would only be able to distinguish the two species by examination of the rami, as in effect he states with regard to *his C. elegans*. And again, I cannot brush aside his statement that the stomach was thread-like, when I know how particularly he was interested in the structure of the alimentary canal and in the appearances presented when the rotifers were fed with indigo or other pigments.

2.—*Callidina rediviva*, as stated above, was clearly a pellet-maker, and had a stomach with a wide lumen. It had two teeth on each ramus, and some resemblance to *Philodina roseola* in colour and form. It occurred in sand from a rain-water gutter in Ehrenberg's house. These details were given in 1838. At a later date, 1848 (**7**), Ehrenberg states that the colour is brick-red and that the body is spindle-shaped. The two-toothed pellet-makers known to-day are comparatively few. The above particulars apply best in my opinion to *Habrotrocha bidens* (Gosse), which has the spindle-shaped body and a superficial resemblance to *P. roseola*; but I have never seen it of a reddish colour, but always colourless or nearly so. To regard the two forms as identical on such faint particulars and resemblance would not, I think, be satisfactory.

3.—*Philodina hirsuta*, Ehrenberg, wrongly ascribed to Pritchard by Janson (**38**), appears to have been accepted by the last author solely upon the faith of its supposed recognition by Anderson (**30**), who in turn seems to have been misled by a ludicrous error in Pritchard's *Infusoria* (1861 edition). In Ehrenberg's description the spurs are thus described: "Pedis corniculis dorsualibus praelongis," the phrase meaning in modern terminology "Spurs very long," but translated in Pritchard as "Foot prolonged by dorsal spines." Anderson remarks that the foot is not prolonged by dorsal spines, and figures a species with quite short spurs, which cannot possibly be the species seen by Ehrenberg. If *Philodina commensalis* of Western be really viviparous as described (of which I have doubts) it is possible that it is a rediscovery of the original *P. hirsuta*, as not only does it fit the few particulars given by Ehrenberg, but I have also seen it partially covered with hair-like bodies, noticed both by Ehrenberg and by Anderson on their respective species. It is now well understood that the supposed "down" does not really appertain to the rotifer, but is a parasitic fungoid growth, either a species of Cladothrix or allied thereto. A similar growth was seen on examples sent to me of *Anomopus telphusae*, which, like *P. commensalis*, is itself of parasitic habits.

4.—*Callidina socialis* Kellicott is probably a good species, but was quite inadequately described by its discoverer, who thought it sufficient to differentiate his species from *Philodina parasitica* as the only Bdelloid previously known to be ectoparasitic upon fresh-water animals, and omitted in particular to ascertain whether it was oviparous or viviparous, and whether it had three or four toes. Janson, who considered that *Rotifer magnicalcarata* (Parsons) is identical with *C. socialis*, assumed that the latter was viviparous and had three toes like Parsons's species. In my view it is quite as likely to have been oviparous and four-toed like *P. commensalis* Western (described as viviparous, but I think in error). There are now known quite a number of these ectoparasitic species, and any amended description of the true *C. socialis* would have to take these into consideration. Meanwhile I retain as valid the *R. magnicalcarata* (Parsons), which I have repeatedly found and which is a much larger form than that described by Janson, attaining sometimes a length of 720 μ or $\frac{1}{35}$ inch. Janson's dimensions and details apply very well to another smaller form, found by Murray in Scotland and myself in England, which has the same sword-like spurs as *P. commensalis* and *R. magnicalcarata*, and like these species is usually found on Asellus. This third form resembles *P. commensalis* very closely in general appearance, but is viviparous, three-toed, and blind. In *P. commensalis* the eyes are frequently very difficult to define, and I am inclined to believe that Western took the character "viviparous" from examples of this third form which he had failed to distinguish from the true *commensalis*.

5.—*Philodina hexodonta* Bergendal. A form found some years ago in Scotland by Murray, and more recently by myself, was at first referred to the above species, in view of the approximation of the number of teeth (5—5) to that stated by Bergendal. It differs from it, however, in almost every other detail given by that writer. For instance, *P. hexodonta* is said to have a body resembling that of *P. roseola*, but not reddish; and to have spurs so swollen at the base that there is no interstice between them. The Scottish form is quite unlike *P. roseola* in general outline; the proportionate length of the foot is very different, the body is often reddish, and there is a distinct interspace between the short, acute spurs.

After further consideration I came to the conclusion that the Scottish specimens must be referred to the *Philodina collaris* of Ehrenberg, a species hitherto unrecognised. It is unfortunate that with regard to this very species Ehrenberg was unable to state the number of teeth, as this detail would have been of great value. But I rely less upon the general details given of *P. collaris* than upon the description and figure of the stomach, which prove clearly enough that this species was a pellet-maker, and had a stomach with the wide lumen usual among pellet-making forms.

The Scottish species is the only pellet-maker known which has two eyes in the neck, or, to locate them more precisely, in the brain, and it further agrees with Ehrenberg's description in having a small corona, and in the eyes being round. I did not observe in my own specimens that there was any distinct swelling of the neck such as Ehrenberg describes; but he appears to indicate that annulus-like thickening of the skin of the post-oral segment which is noticeable in many species. As these are nearly all pellet-making forms, this detail supports my view that *P. collaris* was a pellet-maker. In accordance with that view, and in the belief that the Scottish specimens are more correctly to be assigned to *P. collaris*, I have included Ehrenberg's species as recognisable, and placed *P. hexodonta* among those which are insufficiently described.

It seems probable that the specimens which Bilfinger (**68**) assigned to *P. hexodonta* were similar to the Scottish examples.

6.—*Rotifer hapticus* Gosse. Neither Murray nor myself has met with any species which rivals *R. macroceros* in the length of the dorsal antenna but lacks the tapping motion characteristic of the latter form. But the whole description given by Gosse is so lacking in definite detail that there can be no question of its insufficiency. Indeed, the whole central group of the genus Rotifer, viz. *R. vulgaris* and its nearer relations, amongst which *R. hapticus* is probably to be reckoned, stands greatly in need of a much more critical examination than it has yet received.

7.—*Callidina bihamata* Gosse. The value of the description of this species rests solely upon the reality of the two "hooks" at the apex of the rostrum. It seems certain that the supposed "hooks" were simply the lateral presentment of the rostral lamellae, possessed more or less conspicuously by every Bdelloid known, and which in certain positions might appear to be crossed hooks if imperfectly seen.

8.—*Callidina pigra* Gosse is probably *Habrotrocha constricta* (Dujardin).

9.—*Callidina angusta* Bryce. I had proposed to include this species in the doubtful list, but whilst these notes were in preparation I have been informed by Mr. Murray that he has recently found specimens which agree fairly well with the details noted in my description, although this could perhaps be amplified with advantage. Judging from his specimens he thought that the species seemed to be related to *Callidina habita* Bryce.

10.—*Philodina parasitica* Marchoux is probably a distinct species, but the description is very insufficient, and the specific name has been already appropriated to Giglioli's species, which would possibly prove to be a congener.

11.—*Callidina ornata*, *Rotifer quadrioculatus*, *Philodina obesa*, and *P. decurvicornis*, all described by Murray, are now regarded by him as doubtful, pending further examination.

BIBLIOGRAPHY.

Restricted to works dealing with the classification of the Bdelloida, or containing original descriptions or supplementary details of species.

1. 1803. Schrank : *Fauna boica*, III., 2, p. 110.

2. 1830. G. C. Ehrenberg : Beiträge zur Kenntniss der Organismen der Infusorien, etc. *Abhand. der Berliner Akad. der Wiss.*

3. 1831. G. C. Ehrenberg : Über die Entwickelung und Lebensdauer der Infusionsthiere, *Abhand. der Berliner Akad. der Wiss.*

4. 1838. G. C. Ehrenberg : Die Infusionsthierchen als vollkommene Organismen.

5. 1840. G. C. Ehrenberg : Note in *Verhand. der Berliner Akad. der Wiss.*, p. 197.

6. 1841. M. F. Dujardin : Histoire naturelle des Zoophytes ; Infusoires in, *Suites à Buffon.*

7. 1848. G. C. Ehrenberg: Fortgesetzte Beobachtungen über atmosphaerische Mikroskopische Organismen, *Verhand. der Berliner Akad. der Wiss.*, p. 380.

8. 1851. P. H. Gosse: A Catalogue of Rotifera found in Britain, *Ann. Mag. Nat. Hist.*, Ser. II., Vol. VIII.

9. 1852. Perty: Zur Kenntniss der kleinsten Lebensformen.

10. 1853. G. C. Ehrenberg: Über neue Anschauungen des kleinsten nördlichen Polarlebens, *Verhand. der Berlin Akad. der Wiss.*, p. 529.

11. 1857. L. K. Schmarda: Neue wirbellose Thiere, etc., Bd. I., pp. 47–66.

12. 1863. H. Giglioli: On the genus Callidina, *Quart. Journ. Micr. Science*, N. S., Vol. III., p. 237.

13. 1868. E. Ray Lankester: Note on the Synaptae of Guernsey, etc., and a New Parasitic Rotifer, *Quart. Journ. Micr. Science*, N. S., Vol. VIII., p. 53.

14. 1870. S. Bartsch: Die Räderthiere und ihre bei Tübingen beobachteten Arten, *Jahreshefte des Vereins für Vaterländische Naturkunde in Württemberg*, Stuttgart.

15. 1873. H. Davis: A New Callidina, etc., *Monthly Micr. Journ.*, Vol. IX., p. 201.

16. 1877. S. Bartsch: Rotatoria Hungariae.

17. 1884. C. T. Hudson: An Attempt to reclassify the Rotifera, *Quart. Journ. Micr. Science*, N. S., Vol. XXIV., p. 335.

18. 1886. W. Milne: On the Defectiveness of the Eye-spot as a Means of Generic Distinction in the Philodinaea, etc., *Proc. Phil. Soc.*, Glasgow.

19. 1886–9. C. T. Hudson & P. H. Gosse: The Rotifera or Wheel Animalcules, 2 vols., 1886–7; Supplement, 1889.

20. 1886. Carl Zelinka: Über die Symbiose und Anatomie von Rotatorien aus dem genus Callidina; Studien über Räderthiere; *Jen. Zeitsch. f. Naturwiss. Zool.*, Bd. XLIV., p. 396.

21. 1887. P. H. Gosse: Twenty-four New Species of Rotifera, *Journ. Roy. Micr. Soc.*, p. 1.

22. 1887. P. H. GOSSE: Twenty-four more New Species of Rotifera, *Journ. Roy. Micr. Soc.*, p. 861.

23. 1888. W. MILNE: Rotifer as a Parasite or Tube-dweller, *Proc. Phil. Soc.*, Glasgow.

24. 1888. D. S. KELLICOTT: Partial List of Rotifera of Shiawassee River, *Proc. Amer. Soc. Micr.*, Vol. X.

25. 1888. CARL ZELINKA: Der Raumparasitismus und die Anatomie von Discopus Synaptae; Studien über Räderthiere, *Zeitsch. f. wiss. Zool.* (Jena), Bd. XLVIII., p. 353.

26. 1888. E. F. WEBER: Notes sur quelques Rotateurs des Environs de Genève, *Arch. de Biologie.*

27. 1889. L. PLATE: Über die Rotatorien-fauna des bottnischen Meerbusens, *Zeitsch. f. wiss. Zool.* (Jena), Bd. XLIX., p. 1.

28. 1890. G. WESTERN: Notes on Phil. macrostyla and Rotifer citrinus, *Journ. Quek. Micr. Club*, Ser. II., Vol. IV., p. 87.

29. 1891. CARL ZELINKA: Zur Entwickelungsgeschichte der Räderthiere, etc., Studien über Räderthiere, *Zeitsch. f. wiss. Zool.* (Jena), Bd. LIII., p. 323.

30. 1891. H. H. ANDERSON: Notes on Indian Rotifers, *Journ. Asiatic Soc. Bengal* (Calcutta), Vol. LVIII., p. 345.

31. 1891–2. D. BERGENDAL: Beiträge zur Fauna Grönlands, I. Zur Rotatorienfauna Grönlands, *Kongl. Fysiog. Sällskapets Handlingar.*

32. 1892. F. A. PARSONS: Notes on Two Rotifers found in Epping Forest, *Journ. Quek. Micr. Club*, Ser. II., Vol. IV., p. 378.

33. 1892. DAVID BRYCE: On the Macrotrachelous Callidinae, *Journ. Quek. Micr. Club*, Ser. II., Vol. V., p. 15.

34. 1892. P. G. THOMPSON: Moss-haunting Rotifers, *Science Gossip*, Vol. XXVIII., p. 56.

35. 1893. G. WESTERN: Notes on Rotifers, etc., *Journ. Quek. Micr. Club*, Ser. II., Vol. V., p. 155.

36. 1893. DAVID BRYCE: On the Adinetadae, *Journ. Quek. Micr. Club*, Ser. II., Vol. V., p. 146.

37. 1893. DAVID BRYCE: On Two New Species of Macrotrachelous Callidinae, *Journ. Quek. Micr. Club*, Ser. II., Vol. V., p. 196.

38. 1893. OTTO JANSON: Versuch einer Übersicht über die Rotatorien-Familie der Philodinaeen, *Abhand. der Naturwiss. Vereins in Bremen.*

39. 1893. L. S. GLASCOTT (Miss): A List of some of the Rotifera of Ireland, *Proc. Roy. Dublin Soc.*, Vol. VIII. (N. S.), p. 29.

40. 1893. E. VON DADAY: Cypridicola parasitica, *Természetrajzi Füsetek XVI.*

41. 1894. DAVID BRYCE: Further Notes on Macrotrachelous Callidinae, *Journ. Quek. Micr. Soc.*, Ser. II., Vol. V., p. 436.

42. 1894. THEOD. BARROIS & E. VON DADAY: Résultats Scientifiques d'un Voyage entrepris en Palestine, etc., *Rotifères, Revue Biologique du Nord de la France*, Lille.

43. 1895. B. NĚMEC: O. ectoparasitech Ligidia, *Vestnik Král Ceské Spolecnosti Nauk*, Prague.

44. 1897. DAVID BRYCE: Contributions to the Non-marine Fauna of Spitsbergen, Part II., Report on the Rotifera, *Proc. Zool. Soc.*, London, p. 793.

45. 1897. A. COLLIN: Eingeweidewürmer und Räderthiere, *Die Thierwelt Ost-Afrikas*, etc., Vol. IV., Part V. (Carl Moebius).

46. 1898. F. W. HILGENDORFF: A Contribution to the Study of the Rotifera of New Zealand, *Trans. N. Z. Inst.*, Vol. XXXI., p. 108.

47. 1898. E. F. WEBER: Faune Rotatorienne du Bassin du Léman, *Revue Suisse de Zoologie*, Geneva, Tome V.

48. 1898. J. E. LORD: On Two New Rotifers, *Journ. Quek. Micr. Club*, Ser. II., Vol. VII., p. 75.

49. 1898. E. MARCHOUX: Note sur un Rotifère vivant dans le tube digestif de larves aquatiques d'inséctes, *Compte Rendu Soc. Biol.*, Tome V., p. 749.

50. 1899. C. WESENBERG LUND: Danmark's Rotifera, Copenhagen.

51. 1902. JAMES MURRAY: Some Scottish Rotifers, etc., *Ann. Scot. Nat. Hist.*, p. 162.

52. 1903. JAMES MURRAY: Some Scottish Rotifers (Bdelloida), *Ann. Scot. Nat. Hist.*, p. 160.

53. 1903. SEBASTIANO PIOVANELLI: Two New Bdelloida commensal in the Branchial Cavities of Telphusa fluviatilis, *Journ. Quek. Micr. Club.*, Ser. II., Vol. VIII., p. 521.

54. 1903. DAVID BRYCE: On Two New Species of Philodina, *Journ. Quek. Micr. Club.*, Ser. II., Vol. VIII., p. 523.

55. 1905. JAMES MURRAY: On a New Family and Twelve New Species of Rotifera of the Order Bdelloida, etc., *Trans. Roy. Soc. Edin.*, Vol. XLI., p. 367.

56. 1906. JAMES MURRAY: The Bdelloid Rotifera of the Forth Area, *Proc. Roy. Phys. Soc. Edin.*, Vol. XVI., p. 215.

57. 1906. JAMES MURRAY: A New Bdelloid Rotifer, Callidina vesicularis, *Journ. Quek. Micr. Club*, Ser. II., Vol. IX., p. 259.

58. 1906. JAMES MURRAY: The Rotifera of the Scottish Lochs, *Trans. Roy. Soc. Edin.*, Vol. XLV., p. 151.

59. 1906. JAMES MURRAY: Some Rotifera of the Sikkim Himalaya, *Journ. Roy. Micr. Soc.*, p. 637.

60. 1907. JAMES MURRAY: Some South American Rotifers, *Amer. Nat.* (Boston), Vol. XLI., p. 97.

61. 1908. JAMES MURRAY: Scottish Rotifers collected by the Lake Survey, *Trans. Roy. Soc. Edin.*, Vol. XLVI., p. 189.

62. 1908. JAMES MURRAY: Arctic Rotifers, etc., *Proc. Roy. Phys. Soc. Edin.*, Vol. XVII., p. 121.

63. 1908. JAMES MURRAY: Philodina macrostyla and its Allies, *Journ. Quek. Micr. Club.*, Ser. II., Vol. X., p. 207.

64. 1908. JAMES MURRAY: Some African Rotifers, *Journ. Roy. Micr. Soc.*, p. 665.

65. 1909. P. DE BEAUCHAMP: Philodina intermedia n. sp. et Remarques sur l'origine des Microdinides, *Bull. Soc. Zool. de France* (Paris), Tome XXXIV.

66. 1910. JAMES MURRAY: Antarctic Rotifera, Brit. Antarctic Expedition, 1907–9, *Reports on the Scientific Investigations*, Part III.

67. 1902. FERD. RICHTERS: Neue Moosbewohner, *Bericht der Senckenbergischen Naturforschenden Gesellschaft in Frankfurt a/M.*

68. 1894. L. BILFINGER: Zur Rotatorienfauna Württembergs, *Jahreshefte des Vereins für vaterl. Naturkunde in Württ.*

69. 1886. O. ZACHARIAS: Können die Rotat. u. Tard. nach vollständiger Austrocknung wieder aufleben oder nicht? *Biol. Centralbl.*, Bd. VI., p. 230.

70. 1903. CERTES: Microbiologie, *Mem. Pontif. Accad. Roman. dei nuovi Lincei* (Rome), Vol. XXI., p. 26.

NAVICULA RHOMBOIDES AND ALLIED FORMS.

By Edward M. Nelson, F.R.M.S.

(*Read June 28th*, 1910.)

The reopening of this old story, now dormant for many years, is due to the receipt from Mr. Chaffey of some slides of a gathering of *N. rhomboides.* This gathering proved to be practically identical with that in two old slides labelled "Amician Test." With regard to the question, "What was the Amician Test?" one cannot do better than study Mr. Karop's excellent paper* on that subject. At the same time the following quotations may be of interest. The first, from an anonymous author, appears as early as 1855: ". . . also the very delicate markings of the Amician test, *Grammatophora subtilissima*, and *Navicula rhomboides*. . . ." A few paragraphs on we find ". . . *N. rhomboides*, the Amician test, and *Grammatophora* are made . . ." Another comes from America in the same year: ". . . we did not try in this way either the Amici test or the Providence *Grammatophora*. . . ."

The first paragraph seems to show that the Amician test is not the *Navicula rhomboides*, the second that it is not a *Grammatophora*, and the third that it is not a Providence *Grammatophora*—whatever that may be.

It is not at all improbable that the Amician Test coming over from the Continent to the Exhibition of 1851 was adopted by Mr. C. M. Topping, who some twelve years previously had started business as a professional microscopic-object mounter. There are two slides in my cabinet labelled "Amician Test." They are dry-mounted spread slides of *N. rhomboides*, imperfectly cleaned. One, the older, is mounted between two covers attached by ornamental paper to a mahogany slip with a hole in it; the other, which was the late Mr. Hugh Powell's own slide (kindly given to me by Mr. Thos. Powell), is mounted on a glass slip also covered with ornamental paper, having Topping's name on it. The words "Amician Test" are in the same handwriting on both,

---

* *Journ. Q.M.C.*, ser. 2, vol. 6, p. 79 (1895).

and we know that the mahogany slip was used by Topping in 1841. In Messrs. Sollitt and Harrison's celebrated paper (read before the British Association at Hull in 1854) there is no mention of either the Amician Test or of *N. rhomboides.* Their work being principally connected with marine and brackish forms may account for the omission of *N. rhomboides* from their list.

Gregory's list of 1853 contains *N. rhomboides*, and that of 1855 both *rhomboides* and *crassinervis.* Roper's list of 1854 contains *crassinervis* and *cuspidata*, but not *rhomboides.* In 1868 M. Mouchet writes* that "*Navicula affinis* and *N. rhomboides* do not resemble each other in any way, either in form or in the fineness of their striae. *Navicula affinis* is always distinguished by the line or nervure running along the margins of the valve, which is gently contracted towards its extremities and the ends of which are rounded off. The striae, although difficult to resolve, are much less closely packed (46–60 in 0·001″) than those of *N. rhomboides.* Different authors, however, have described and drawn the one for the other. The opticians often give to *N. affinis* the name of *N. amici*, no doubt because this diatom was the favourite test of that able microscopist. *N. affinis* is also confounded with the *N. gracilis*, *N. rhombica*, *N. cuspidata*, etc., in such a way that it is sometimes difficult to recognise them. I have said that the two diatoms in question ought not to be confounded. In fact, whilst the *N. affinis*, with the elliptic valve, is pinched up towards its ends, it is quite otherwise with *N. rhomboides*, which has a nearly quadrangular form, and the ends of which are lanceolate. The striae of this diatom (85 in 0·001″) make it a test of the first order." Enough has been said to show that it was after the Exhibition of 1851 that *N. rhomboides*, *crassinervis*, etc., began to be talked about, and diatoms used as test-objects; so these two particular slides may very well be assigned to a date about 1855. We are, however, at present more concerned with what is on the slide, than about their date. These slides have gone bad, *i.e.* sweated, etc., and would not have been preserved had it not been for their historic interest.

A rough examination shows a number of *N. rhomboides*, a few large ones, a few small ones, and many of a medium size, so that if you want a very large or a very small one you have to hunt

---

* *Quart. Journ. Mic. Sci.*, ser. 2, vol. 8, p. 105 (1868).

for it. Another diatom fairly common in the gathering is *Navicula serians.* A more minute examination shows that the rhomboid form is strongly marked, especially in those of a medium size.

The average length of the diatom is 0·0036, which is 4·9 times its breadth; the transverse striae count 72 to 73 in one-thousandth of an inch. The shape of the ends of the raphe are very important; when examined by ordinary illumination, such as would have been used at that day, they appear like a trefoil-headed Gothic window. This diatom will be called in this paper, for the sake of identification, the English *rhomboides.*

To return to our historical narrative: a few years later quite a commotion was aroused in the microscopical world by an announcement from America that somebody's $\frac{1}{4}$-inch objective had resolved the *N. rhomboides.* Subsequently it was found that the *rhomboides* in question was a large and coarse form that had been found at Bennis Lake. (This is now known as the Cherryfield *rhomboides*, which a few years ago Mr. Mainland rediscovered in "Sozodont" tooth powder, from which some of our finest specimens have been obtained.)

This diatom is about twice as long as the English *rhomboides*, and it differs from it in the coarseness of its striation, which is pretty constant at 60,000 per inch; it could therefore be resolved by the $\frac{1}{4}$-inch objectives of that day. Moreover, the shape of the end of the raphe resembles a Romanesque or Norman arch, and the ratio of its length to its breadth is about 5·9; further, the rhombic angle is not nearly so distinctly marked in this diatom. If the diatom were of the same species as the English *rhomboides*, one would expect to find the same rhombic angle, the same trefoil-headed raphe, and a striation nearer 80,000 than 60,000, for the large forms of this Cherryfield *rhomboides* appear to be finer than the small. But to proceed: another *Navicula* brought forward as a test about this time was called the *Frustulia saxonica.* It much resembled the English *rhomboides*, for it had both the rhombic angle and the Gothic termination to its raphe distinctly visible, but it differed, inasmuch as it was smaller and its striation was finer, being about 82,000 to the inch; there was also far less variation in the size of the specimens, its ratio being about 4·3.

The last diatom of the series we have to consider is the

Navicula crassinervis, which, although known almost as early as the *rhomboides*, is put last on the list because its striation is so fine that it was not resolved until much later. It is a very small form, about 0·0016 inch long, its ratio being about 3·8, with a striation about 88,000 per inch. Its shape in outline is elliptical without a trace of any rhombic angle; it also resembles *Frustulia* in the uniformity of the size of its valves. When once seen it cannot possibly be mistaken for any of the others. There is, however, another diatom in the same gathering as the English *rhomboides*. It can be distinguished by having no rhombic angle, the sides having much flatter curves, and at the ends the sides come in with a shoulder. The end of the raphe is Romanesque, like the American Cherryfield *rhomboides*; its transverse striae count 72 in the thousandth of an inch. This variety has received an independent name, *Schizonema viridulum*. The shape of the exterior outline of a diatom more often determines its species than any other feature it possesses.

You now have before you a particular description of the four varieties of *rhomboides*, and it is for you to say if they are merely variations of one form growing one from another, or whether they are distinct varieties breeding true. Personally I think they are distinct varieties, but not being a diatom-species expert I decline to make any definite statement about this point. Standing quite outside this branch of diatomic work I can only express astonishment that a species such as *rhomboides* should have been taken out of the genus *Navicula* and made a *Vanheurckia*. If a *rhomboides* is not a *Navicula*, no other diatom can be; and if this precedent, originated by M. de Brébisson in 1867, is to be followed we may expect to find other varieties treated in the same manner: thus *Navicula lyra* may be named *Sollittiana lyra*; *Navicula serians*, *Harrisonii serians*, and so on to complete the confusion.

In conclusion the following suggestion is put forward for your consideration. So long as these minute variations are expressed in words it is almost impossible to estimate from the many different peculiarities or features which a diatom may possess the resultant of the whole of them; if only, however, we could give a numerical value to these minute differences a resultant number could easily be found that would almost stand for the numerical index of the variety.

Let us take these four *Naviculae* we have been considering and see what can be done with them. Obviously their lengths may be expressed in terms of their breadths: this will give at once one numerical value, but not of much use by itself, for there may be many forms whose lengths are, say, five breadths. But this number may be further narrowed down by taking the fineness of the transverse striation into account. This was done, and an interesting relation was discovered, viz. that when the fineness of the transverse striation was multiplied by the length-breadth ratio the constant quantity 35 was obtained. As we are dealing with only a numerical relation, the figures have been cleared of decimals by multiplying by 1,000, and only the number of striae in the one-ten-thousandth of an inch has been used.

For example, the English *rhomboides* has 7·2 transverse striae in the one ten-thousandth of an inch, and its length is about 4·8 or 4·9 times its breadth. Now, 4·85 × 7·2 = 35.

For the Cherryfield *rhomboides* we have 5·85 × 6 = 35
For the *Frustulia saxonica* 4·3 × 8·2 = 35
And for the *Navicula crassinervis* 3·8 × 9·2 = 35.

If then we divide the number of the transverse striae by the length-breadth ratio we shall find a number that will be the numerical index for the variety.

The index for Cherryfield *rhomboides* is 10·3
,, ,, English ,, 14·7
,, ,, *Frustulia saxonica* 19
,, ,, *Navicula crassinervis* 24

On Möller's typen-platte slide are two diatoms; it is required to know what varieties they are. The first has a ratio of 5·6 and 60,000 transverse striae; the dividend is 10·7: it is therefore a Cherryfield *rhomboides*. In the catalogue belonging to the slide it is entered as "a fossil from America." The second has a ratio of 4·65 and 81,000 transverse striae; its index is therefore 17·5: it is a *Frustulia saxonica*. The catalogue calls it "a *N. crassinervis* from Holstein." It is totally unlike a *crassinervis*, for it has the rhombic curve and is 0·0036 in length. We have therefore by this simple means run these two varieties to earth.*

---

* See remarks by J. E. Ingpen (at that time Hon. Sec. Q.M.C.), *M. M. J.*, vol. 17, p. 221 (1877).

It should be understood that this formula must not be read as if it were a mathematical or physical law; it is only meant to be a numerical guide which will probably be found much more useful for purposes of identification than any verbose or vague description of a species.

Formerly a biologist's stock-in-trade was a ready pen, a vocabulary of dog Latin and bastard Greek, and a glorified grandmother's magnifying-glass; but we trust that that day is past, and that something more is required of those who undertake the work of naming and classifying the Diatomaceae. Hitherto diatoms have been considered important mainly on account of their extreme beauty and also as affording objects of interest to dilettanti, but for real biological purposes they had scarcely any place. The editor of a biological journal who would have grudged the space for a single paragraph on diatoms would have willingly found room for twenty pages of a smartly written essay on *Eozoon canadense*; but *tempora mutantur*. It is now recognised that diatoms are to marine life what grass is to the land animals. A diatom lives on the inorganic chemical substances in sea water and so becomes suitable food for Copepods, etc., which in turn are eaten by Crustacea, which constitute the food of large fishes. So it appears that diatoms are of the highest importance to us even from an economic point of view, for if we want good fishes we must look after our diatoms.

It is surprising how very little we really know about diatoms. Hardly anything is known about their reproduction. One of the most important papers on this subject was read at this club by Mr. Buffham, and is printed in our journal.* Hardly anything is known of their life-history. In those parts of the world where one would expect to find them in great abundance they are comparatively few; and in other places, where one would think that they could not possibly live, they are to be found in enormous numbers. We are still in total ignorance of the causes of their movements. So then we may take it that the study of the Diatomaceae is still in its infancy and, consequently, there is a grand microscopic harvest waiting for an energetic Queketter to reap.

---

* *Journ. Q.M.C.*, ser. 2, vol. 2, p. 131, pls. 7 and 8 (1885).

SOME NEW AFRICAN SPECIES OF *VOLVOX*.

By G. S. West, M.A., D.Sc., F.L.S., Professor of Botany at the University of Birmingham.

(*Communicated by Mr. C. F. Rousselet, October 25th*, 1910.)

The present short paper is largely a report on a number of slides of *Volvox* recently submitted to me for examination by Mr. C. F. Rousselet. They embraced a series of specimens of *Volvox globator*, *Volvox aureus*, and several other forms of considerable interest.

The characters of the two European species, *V. globator* and *V. aureus*, are now very well known and their specific distinction clearly established. This was due in the first instance to the researches of Klein,* and his investigations have been repeatedly confirmed. Overton † has also pointed out further distinctions. In this country Hick ‡ was the first to direct attention to the fact that these two distinct species were widely distributed. The distinguishing features are for the most part in the sexual organs and ripe oospores, although each species can be definitely recognised by the structure of the vegetative colony.

It is not at all uncommon to find the two species mixed in the same pool or pond, and perhaps the appended synopsis of their distinctive characters may prove useful. In both species the vegetative (or asexual) colonies are globular and the male colonies ovoid, but in *V. globator* the female colonies are almost invariably globose, while in *V. aureus* they may occasionally be ovoid.

---

* Klein in Pringsheim's *Jahrb. für wissensch. Botan.*, xx., 1889.

† Overton in *Botan. Centralbl.*, xxix., 1889.

‡ Hick in *Trans. Manchester Microscopical Society*, 1891.

The contrasted characters of these species are as follows:—

Volvox globator Ehrenb. [=*V. monoicus* Cohn.]	**Volvox aureus** Ehrenb. [=*V. minor* Stein; *V. dioicus* Cohn.]
Diam. of colonies, 420–800μ.	Diam. of colonies, 200–680μ.
Number of cells, 1,000–15,000.	Number of cells, 200–4,400.
Cells small, angular in surface view, and somewhat irregularly produced at the angles.	Cells larger, almost round in surface view.
Connecting strands of protoplasm thick and continuous with processes of cells.	Connecting strands of protoplasm very delicate (as fine as the cilia) and sharply marked off from the cells.
Contractile vacuoles, 2–6 (commonly 4).	Contractile vacuoles, 2.
Daughter-colonies, regularly 8.	Daughter-colonies, 4–14.
Oospores, 12–40 (average 30); outer wall of ripe oospore verrucose with conical warts.	Oospores 3–9 (average 6); outer wall of ripe oospore smooth.
Each androgonidium produces 64 or 128 (rarely 256) antherozoids.	Each androgonidium produces 16 or 32 antherozoids.
Antherozoids slender, with elongated nucleus and laterally attached cilia.	Antherozoids less elongated, with spherical nucleus and terminal cilia.
Antherozoids and oospheres commonly produced in different sexual colonies.	Antherozoids and oospheres usually in the same sexual colony.

Mr. Rousselet's slides contained both these species, a collection made in Baden-Baden in 1906, containing some very fine examples of *V. globator* with 20–32 ripe oospores. A collection made by Mr. Rousselet at Totteridge contained fine male colonies of *V. aureus*.

There is also a third European species—*V. tertius* A. Meyer *—which is less well known, and can only be regarded as doubt-

---

* A. Meyer in *Botan. Zeitung*, xi. and xii., 1896.

fully distinct. In this species there are no connecting strands between the cells of the adult colony.

Quite recently two papers on American species of *Volvox* have appeared by J. H. Powers,* in which the author describes several new forms under the names of *V. spermatosphaera*, *V. Weismannia*, and *V. perglobator*. The distinctions drawn up by Powers are concerned principally with the development of the reproductive colonies and the reproductive cells. He thinks it likely that the European species do not exist in America, and that the American species of *Volvox* are distinct races.

Volvox Rousseleti, sp. nov.

(Pl. 3, Figs. 1–7.)

In September 1905, at the time of the British Association's visit to South Africa, Mr. Rousselet collected from a pool near the station at Gwaai in Rhodesia a truly remarkable species of *Volvox*. All the specimens sent me for examination were purely vegetative. Yet, notwithstanding the entire lack of knowledge of the sexual colonies, I have no hesitation in regarding these specimens as vegetative (or asexual) colonies of a new species of the genus.

The adult colonies are large and globose, measuring 1,125–1,240μ in diameter. In appearance they are very robust, much more so than those of any other species of *Volvox*, a feature which is due to the dense crowding of the constituent cells. The number of cells in the colony could be very easily estimated, and was found to vary from about 25,000 to rather more than 50,000. It is this enormous number of cells constituting the colony, and the density of their arrangement, which form the diagnostic features of this large African species.

The cells are 4–6·5μ in diameter, and are separated by intervening spaces of less than their own breadth. In surface view (*vide* Fig. 7) they are seen to be somewhat angular, and in all the specimens they appeared to possess relatively stout protoplasmic connecting processes. I say "appeared to possess" because it is unsafe to give a decided opinion on this point unless the colonies have been fixed with the greatest care.

The number of daughter-colonies produced by one individual

---

* J. H. Powers in *Trans. Amer. Microscop. Soc.*, xxvii., 1905; xxviii., 1906.

was regularly eight, and when set free each had a diameter of about 370μ. In this stage the cells apparently touch one another, a condition which exists almost up to the time the young colonies have attained a diameter of 800–850μ. It is at this period that the first formation of daughter-colonies can be observed in the young colony (*vide* Fig. 5).

In size this species is similar to the American *V. perglobator* Powers, but the cells in the latter species are so far removed from one another that "the appearance under a moderate magnification is that of a sponge-like reticulum," whereas the attainment of a large size by the colonies of *V. Rousseleti* has been accompanied by such an increase in the number of cells that the colony has a much more solid and robust appearance than is exhibited by any other species of *Volvox*.

Volvox africanus sp. nov.

(Pl. 3, Figs. 8–10.)

A curious form of *Volvox* was obtained from the Albert Nyanza by Mr. R. T. Leiper, who accompanied the expedition dispatched to Uganda by the Egyptian Survey Department in July 1907. It occurred both in a sample of plankton and in material collected in thirty feet of water. The material was sent to me for examination by Dr. W. A. Cunnington, and, in addition to specimens I observed in this material, Mr. C. F. Rousselet also forwarded me some carefully mounted slides of selected specimens.

I have already recorded this *Volvox* as "*Volvox aureus* Ehrenb. (a form),"* but since that time I have examined many more specimens and find constant characters scarcely in keeping with those of *V. aureus*.

The colonies are of approximately the same size as those of *V. aureus*, but differ in being constantly ovoid or egg-shaped, and in the nature of the daughter-colonies.

From one to four daughter-colonies arise in the adult asexual coenobium, and they soon attain a large size, growing until they become flattened by compression. They almost entirely fill up the internal cavity of the parent, and they themselves show well-developed daughter-colonies long before their escape from the

---

* G. S. West in *Journ. Bot.*, July 1909.

mother-colony. In fact, a fourth generation is not at all uncommon (*vide* Fig. 10), and all the specimens seen exhibited to a marked degree the three generations. The ovoid form of the colony is not entirely due to compression within the confined space of the mother-colony, as examples were observed in which only one parthenogonidium had developed into a daughter-colony, and this was of the typical ovoid form although there was ample room for its development.

The cells of the adult colony are similar to those of *V. aureus* in relative number and spacing, but no protoplasmic connections could be observed. Length of colony, 345–610μ; breadth, 295–480μ.

One male colony was associated with the purely asexual colonies, and perhaps represents the male colony of the same species of *Volvox*. This colony exhibited a distinct polarity in the development of the androgonidia, and differed in no essential particular from the male colony of *V. aureus*. It is to be regretted that a number of sexual colonies in various stages could not be found, as one might then have been much more certain of the true relationships of this species of *Volvox*.

From available material, I can only suggest that it is a *Volvox* near to *V. aureus*, but differing in the form of its vegetative (or asexual) colonies, in the great development and compression of the daughter-colonies before they are set free, and in the fact that three (and often four) generations of colonies always appear to be well marked. These characters appear to be sufficient for its identification, and it seems proper to regard it as a new species or new race of *Volvox* for which I would suggest the name *V. africanus*.

As yet no trace of this *Volvox* has been seen from the other large lakes of Central Africa, and it should be remarked that they have been much more thoroughly investigated than the Albert Nyanza.

A SPECIES OF *VOLVOX* FROM AUSTRALIA.

One of Mr. Rousselet's slides contained two species of *Volvox* from Heidelberg, near Melbourne, Australia.* One of these is

---

* These were collected by Mr. W. J. Hocking and sent to Mr. D. J Scourfield.

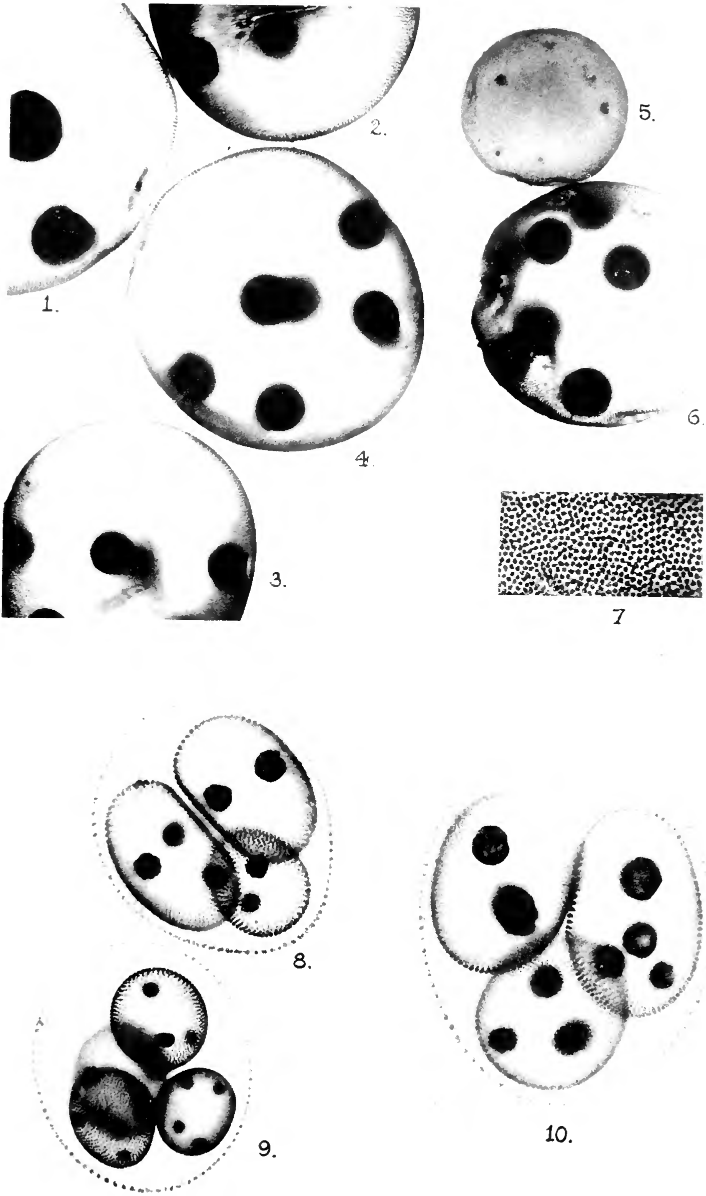
typical *V. aureus*, but the other is a much larger species closely approaching *V. Rousseleti*. The adult colonies measure 700–1,110μ in diameter and the cells are decidedly crowded. The colonies exhibit a slight polarity owing to a more or less distinct concentration of the cells towards one pole. The material was, however, insufficient to be certain of the identity of this species.

DESCRIPTION OF PLATE 3.

Figs. 1–7. *Volvox Rousseleti* sp. nov., from Rhodesia. Figs. 1–6, × 38; Fig. 7, surface view of part of colony, × 84.

,, 8–10. *Volvox africanus* sp. nov., from the Albert Nyanza. Figs. 8 and 9, × 70; Fig. 10, × 84.

Three generations are clearly seen in Figs. 8 and 9, and in Fig. 10 four generations may be seen.



G. S. West. Photomicrogr.

AFRICAN SPECIES OF VOLVOX.

TWO NEW SPECIES OF *CASSIDULINA.*

By Henry Sidebottom.

(*Communicated by Mr. Arthur Earland, October 25th,* 1910.)

Carpenter states in his *Introduction to the Study of the Foraminifera* that the "genus *Cassidulina* was first established by M. d'Orbigny, in 1826, for a peculiar type which does not appear to have been recognised by any previous observer."

He states that "the texture of the shell of *Cassidulina* is hyaline and finely porous, like that of the smaller *Buliminae*; and it resembles that type also in the character of its aperture. In fact, if we imagine a biserial *Bulimina* to be completely rolled upon itself, so as to form an equilateral or nearly equilateral spire, we should have the essential features of a *Cassidulina.* The arrangement of the chambers, as it shows itself externally, has a semblance of irregularity which does not really belong to it; the apparent irregularity being really due to the interdigitation of the chambers of the two alternating series, some of which may be made to appear by the obliquity of the spire as if they were small and intercalated."

Carpenter also states: "In the finely porous texture of its shell and its slit-like aperture, it is obviously more allied to *Bulimina* than to *Textularia*; whilst in the biserial interdigitate arrangement of its chambers, it is more closely akin to *Textularia* than to the typical *Bulimina.*"

Brady, in the *Challenger Report,* writes: "The distribution of living *Cassidulinae* is world-wide, almost irrespective of latitude or depth. In the fossil condition the genus is not very common; it makes its appearance in the Eocene period and is represented from time to time in beds of later geological age."

Cassidulina elegans sp. nov. (Pl. 4, Fig. 1).

Test somewhat globular, slightly compressed at the sides. Sutures sunk, the upper portion of the chambers being raised and sometimes almost angular. The lower parts of the chambers are more transparent than the upper. The orifice is an oblique, curved, loop-like slit with a raised edge. The test is of a delicate cream-colour, is slightly roughened and the interdigitation of the chambers is well marked.

The two specimens in my possession are evidently in the recent condition. They were given to me by my brother-in-law, who had them from the late Mr. Chaffers, of Manchester. Unfortunately no locality is indicated. I have, by the courtesy of Mr. Chaffers's son, gone through a large portion of his father's collection of Foraminifera in the hope of meeting with duplicate specimens marked with the locality, but have failed to find any trace of them. The two shells vary a little in shape, the one figured being rather longer than the other and, therefore, not so globular.

The one figured is also more regularly built up than the other specimen. This latter has the "coil" twisted a little to one side. There are not many species in this genus, so that it is very interesting to chronicle a really good find.

Within a few days of writing the above, I was looking through some slides of Foraminifera, now in my possession, belonging to the late Mr. Thornhill, of Castle Bellingham, Ireland, when I came upon a *decorated Cassidulina* with the locality given. Looking through the pill-box of material in which the specimen was found. I was delighted not only to find some more, but, strangely enough, to come across five good examples of *Cassidulina elegans*, above described, and for which I had wanted a locality. They agree with the drawings, except that some of them are rather more globular in shape. Of course, as one would expect, they vary a little in size.

The locality and particulars are as follows: H.M.S. *Waterwitch*, S.W. Pacific, Station 159; lat. 19° 04′ S.; long. 179° 43′ E.; 1,050 fms.

Cassidulina decorata sp. nov. (Pl. 4, Fig. 2).

Test nearly globular. The face slightly compressed. The orifice is an oblique, curved, loop-like slit with raised border, and the sutures (a little sunk) only show immediately below it.

The whole of the test, except in the region of the orifice, is decorated with a network of irregular costae. No indication of the sutures is traceable on the back of the test, but by using a weak solution of hydrochloric acid I was able partially to obliterate the costae, and to make out the interdigitation of the chambers.

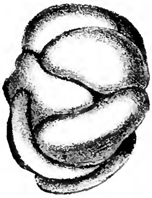
The markings indicated in the drawings must not be taken as being exact, for they are too complicated to draw quite correctly on so small a scale, but they are quite near enough for the identification of other specimens. The groundwork between the costae is rough. The shape of the test is very similar to *Cassidulina calabra* Seguenza, as figured in the *Challenger Report*, which also occurs at this station, and of which *Cassidulina decorata* may possibly be a decorated variety. Even after using the acid I could detect no sinking of the sutures beyond that mentioned above.

Locality and particulars as follows: H.M.S. *Waterwitch*, S.W.

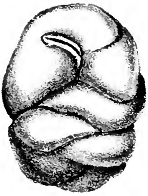
Pacific, Station 159; lat. 19° 04′ S.; long. 179° 43′ E.; 1,050 fms. Also occurs at Station 256, lat. 16° 9′ S.; long. 179° 47′ E.; 505 fms.

EXPLANATION OF PLATE 4.

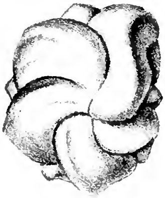
Fig. 1. *Cassidulina elegans* sp. nov. × 50.
Ventral, (*b*) Lateral, (*c*) Dorsal aspect.
Fig. 2. *Cassidulina decorata* sp. nov. × 50.
Ventral, (*b*) Lateral, (*c*) Dorsal aspect.



1 c.



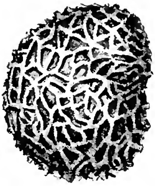
1.



1 b.

2 c.

2.



2 b.

H.S. del. A.H.Searle lith.

Cassidulina sp. novae.

A CONTRIBUTION TO THE LIST OF HYDRACHNIDAE FOUND IN THE EAST AFRICAN LAKES.

By Charles D. Soar, F.R.M.S.

(Read October 25th, 1910.)

The material on which this paper is based was placed in my hands for examination, in the spring of this year, by Mr. C. F. Rousselet, F.R.M.S. It consists of three tubes containing Hydrachnids collected during the third Tanganyika Expedition, conducted by Dr. W. A. Cunnington, F.Z.S., 1904–5. Each tube represents the collection made from one of the three great lakes: (1) Victoria Nyanza, (2) Nyassa, (3) Tanganyika. This is not the only record from East Africa, as Dr. Koenike, of Bremen, Mr. Halbert, of Dublin, and Dr. Daday, of Budapest, have all recorded water-mites from the same great lakes; those described by Mr. Halbert (2) having been found by the above expedition in Lake Tanganyika. A complete list of the Hydrachnidae from these lakes, as at present known, is added at the end of this paper.

The collection from Victoria Nyanza (Tube No. 1) contained only one species I was able to identify (*Unionicula figuralis* Koch.); the remaining specimens were in bad condition and immature.

From Lake Tanganyika. (Tube No. 2.)

Diplodontus despiciens Müll.

Two nymphs of this mite were found in the tube. The colour was entirely gone; in life they were no doubt the usual red colour. I have found a number of yellow-coloured mites of this species in Suffolk, which I think is very rare, as I have not found them elsewhere. The colouring of the soft-bodied mites is always removed by the preservative in which they are placed. The red-coloured mites of this species are very common.

Forelia liliacea Müll.

One female, which fits in exactly with the type of the species in all but one particular; and that is, the palpi are a little thicker in the African form. The male of *F. liliacea* shows the specific differences in a more marked manner than the female, but, unfortunately, the male is not represented in the collection. So, until a male reaches us to put the question quite at rest, I propose to call it *Forelia liliacea* Müll. It is really so close to the European species that I think at the most it can only be a variety.

Neumania papillosa sp. nov. (Pl. 5., Figs. 1, 2.)

FEMALE: Body about 0·64 mm. long, in shape oblong with angles well-rounded, anterior line of body slightly bent inwards. Papillae projecting beyond both posterior and anterior margin; on the dorsal surface are two rows of papillae, three on each side near the outside marginal line. The length of the papillae is about 0·04 mm. The specimen is about the same as the type species of the genus. The acetabula appear to be free on the body skin, as figured (Fig. 2); if there are plates they are so faint that I have not been able to detect them. In Koenike's figure of *Neumania megalommata* ♀ the plates are figured very faintly; however, they are there. In this new species, *N. papillosa*, there are five acetabula on each side of the genital opening. The legs are very sparingly provided with spines, which is rather different from some of the well-known species of this genus. Take *N. spinipes* Müll., for example, where the legs have a great number of spines and swimming hairs. The palpi I have not been able to figure; the two or three specimens which I had were not in good enough condition to get a satisfactory palpus from. The specimens were all females, and full of ova. It is not at all unusual for members of this genus to have a number of papillae projecting beyond the marginal line of the body. *N. umbonata* Koen, has three on each side, but they are directly on the marginal line and not set a little way on the dorsal surface, as we find in this species; although Koenike's species has three papillae on each side, it has not the two we find on the posterior margin, or rather four, for there are two on each side of the median line in *N. papillosa*.

Unionicula figuralis Koen.

Two females of this species.

Mideopsis minuta sp. nov. (Pl. 5, Figs. 8, 9.)

This is a very small species, and is probably a male. The unusual point about it is that the genital area has four acetabula on each side of the genital fissure. This appears to be a very unusual number among the water-mites. The length of this species is only 0·48 mm. The colour is well preserved, the triangular shaded patch in the anterior region being a Prussian blue; this was, in fact, the only mite in the collection in which the colour had been preserved. But this is usual with all the hard-skinned forms. There was only one specimen in the collection.

Hygrobates edentipalpis sp. nov. (Pl. 5, Figs. 3–7.)

FEMALE: Length, 0·72 mm.; breadth, 0·60 mm. Well rounded on anterior margin. It differs very little from the other members of this genus except in the palpi. The palpi of all the species of this genus, as far as I know, are more or less covered with teeth on the inner edge of the second and third segments. On the palpi of this mite I can find no such teeth, so I propose to call it *Hygrobates edentipalpis*. Several females and males were found in the collection. The females were all full of ova; some had three, others had four eggs. The male is a little smaller than the female, but the only difference in surface structure is in the genital area.

The palpus (Fig. 5), which is the most important feature, readily distinguishes it from other species of the genus. In length it measures about 0·35 mm. The segments taken separately measure: first, 0·02 mm.; second, 0·10 mm.; third, 0·06 mm.; fourth, 0·13 mm.; and the fifth, 0·04 mm. The fourth segment is the longest, and has a long thin hair about the middle of the inner edge. This hair is about 0·06 mm. in length.

FROM LAKE NYASSA. (Tube No. 3.)

Unionicula cunningtoni sp. nov. (Pl. 5, Figs. 10–12.)

This mite is very like *Unionicula figuralis* Koch, but on closer examination it is seen to be different in two or three material points. The last segment of the palpus has three distinct teeth, which take up nearly the whole of the segment (Fig. 12). In *U. figuralis* the teeth are hardly perceptible. The acetabula are five on each side of the genital opening—two on the upper plate and three on the lower. The three lower ones are placed near the marginal line of the plate. In *U. figuralis* the median acetabulum is placed nearly in the centre of the plate. Exactly behind the eyes is a long split seta (Fig. 10). I know of no other mite having this distinguishing characteristic. The length of the body of the female is about 1·10 mm.

COMPLETE LIST OF HYDRACHNIDS FOUND IN THE EAST AFRICAN LAKES

(Including, as far as I have been able to ascertain, all those previously recorded. The figures in brackets refer to the bibliography.)

1.	*Unionicula crassipes* Müll.	Victoria Nyanza.		(1, 5.)
2.	,, *borgerti* Daday	,,	,,	(1, 5.)
3.	,, *falcifer* Daday	,,	,,	(1, 5.)

4. *Unionicula figuralis* Koch. Victoria Nyanza, Lake Tanganyika. (1, 3, 4, 5.)
5. *Unionicula cunningtoni* sp. nov. Lake Nyassa.
6. *Neumania spinipes* Müll. Victoria Nyanza. (5.)
7. „ *papillosa* sp. nov. Lake Tanganyika.
8. „ *paucipora* Koen. Victoria Nyanza. (3, 4.)
9. *Encentridophorus spinifer* Koen. Victoria Nyanza, Lake Nyassa. (2.)
10. *Encentridophorus borgerti* Daday. Victoria Nyanza. (1.)
11. *Arrhenurus plenipalpis* Koen. Lake Nyassa. (2.)
12. *Frontipoda stuhlmanni* Koen. Victoria Nyanza. (1, 4, 5.)
13. *Limnesia armata* Koen. Victoria Nyanza. (1, 4.)
14. *Piona rotundus* Kram. ,, ,, (1, 4.)
15. *Hygrobates edentipalpis* sp. nov. Lake Tanganyika.
16. *Mideopsis minuta* sp. nov. ,, ,,
17. *Diplodontus despiciens* Müll. ,, „ (5.)
18. *Forelia liliacea* Müll. ,, ,, (5.)

BIBLIOGRAPHY.

1. DADAY, E. V. *Plancton-Tiere aus dem Victoria Nyanza*, 1907.
2. HALBERT, J. W. "Zoological Results of the Third Tanganyika Expedition, 1904–5," *Proceedings of the Zool. Soc.*, London, 1906.
3. KOENIKE, F. *Die von Herrn Dr. F. Stuhlmann in Ostafrika.* Hamburg, 1893.
4. KOENIKE, F. *Die Hydrachniden Ostafrikas*, Berlin, 1895.
5. PIERSIG, DR. R. *Das Tierreich Hydrachnidae*, Berlin, 1901.

DESCRIPTION OF PLATE 5.

Neumania papillosa sp. nov.

1. Dorsal surface, ♀. × 42.
2. Ventral surface, ♀. × 42.

Hygrobates edentipalpis sp. nov.

3.	Dorsal surface,	♀.	× 48.
4.	Ventral surface,	♀.	× 48.
5.	Palpus,	♀.	× 168.
6.	Genital area,	♀.	× 168.
7.	,, ,,	♂.	× 168.

Mideopsis minuta sp. nov.

8.	Dorsal surface,	♂.	× 56.
9.	Genital area,	♂.	× 168.

Unionicula cunningtoni sp. nov.

10.	Dorsal surface,	♀.	× 42.
11.	Genital area,	♀.	× 120.
12.	Palpus,	♀.	× 140.

A NOTE ON TWO INSTANCES OF "BREAKING OF THE MERES."

By James Burton.

(*Read April 26th*, 1910.)

The following paragraph occurs in the report given in *The English Mechanic* of the Club's excursion to Totteridge, July 10th, 1909: "A small pond at the roadside was noticed, the water of which was turbid and yellow, as though from clay in suspension. On a hasty examination, however, the presence of some organism was suspected. Under the microscope this was made out to be one of the Myxophyceae—probably *Oscillatoria decolorata* West—perhaps the same as *O. ochracea* Grev. These lower algae are not easy to discriminate; should, however, this example prove to be as expected, its presence in sufficient number deeply to colour the entire pond would be an interesting instance on a small scale of a phenomenon known as 'the breaking of the meres,' when large bodies of fresh water—lakes, etc.,—become temporarily discoloured and rendered unfit for use owing to the excessive multiplication of some of the same class of algae."

I want to bring before you a few further details of this occurrence, and also of a similar case I noticed soon after. Probably not many members have paid attention to the phenomenon known as "the breaking of the meres," notwithstanding the interest attaching to it. It may be defined as that condition of a body of fresh water when it is so permeated with one or more species of microscopic algae as to be visibly affected by their presence. Of course, this definition would include those very common instances where small ponds and roadside pools are coloured by the enormous multiplication of *Euglena* or

Protococcus, and indeed these cases do not differ except in the size of the body of water affected from the more remarkable ones. In Dr. Cooke's *Introduction to Freshwater Algae* there is a great deal of information on the subject, from which it appears that at one time this phenomenon was regarded as a very mysterious process, and its occurrence was attributed to various fanciful causes. In the particular instance referred to the pond is an ordinary roadside horse-pond; it is shallow, and easily accessible on one side, and carters constantly in the hot weather drive their teams into it, and many ducks live there. On previous occasions I have never found anything of value in it, and should have passed it by this time had not Mr. Rousselet kindly called my attention to the fact that there was some organism present to a noticeable extent. At that time, as the report just referred to states, the water was turbid, and streaked with something of a yellow clay-colour. Sticks and small floating objects had this collected round them in greater quantity, and the unfortunate ducks looked generally dirty, with high-water marks on their white bodies of the same hue. With a hand lens the water appeared to be filled with minute rod-like particles, but on the spot nothing further could be observed. During the following week I visited the pond again, and it is not an easy matter to speak of its condition then without an appearance of exaggeration. The whole of the water had lost its transparency, and was streaked and lined, owing to currents caused by wind, with something of an opaque yellow-ochre colour. Sticks and other objects were now covered with a thick deposit of this substance, which was present to such an extent on the lee side that the water was thickened with it, and was about the consistency of thin oatmeal porridge. It was impossible to use the collecting net; a single dip filled the bag with material of such solidity that it would not run down into the tube, and when lifted out was almost as thick as dough, or like thin glazier's putty and almost exactly of that colour. The ducks had left the pond altogether, and certainly no carman would have thought for a moment of watering his horses there. On the bank the substance was collected in masses; the small waves caused by the wind had driven it on shore, and it would have been easy to gather it up with a shovel. When we consider what the organism is, and its minute size, it seems marvellous that such an amount could have originated in such a small area of water. From this time the organism gradually lessened; and on a visit about a month after, the pond had regained its normal condition and appearance, and though I diligently searched for half an hour I could not procure a single specimen.

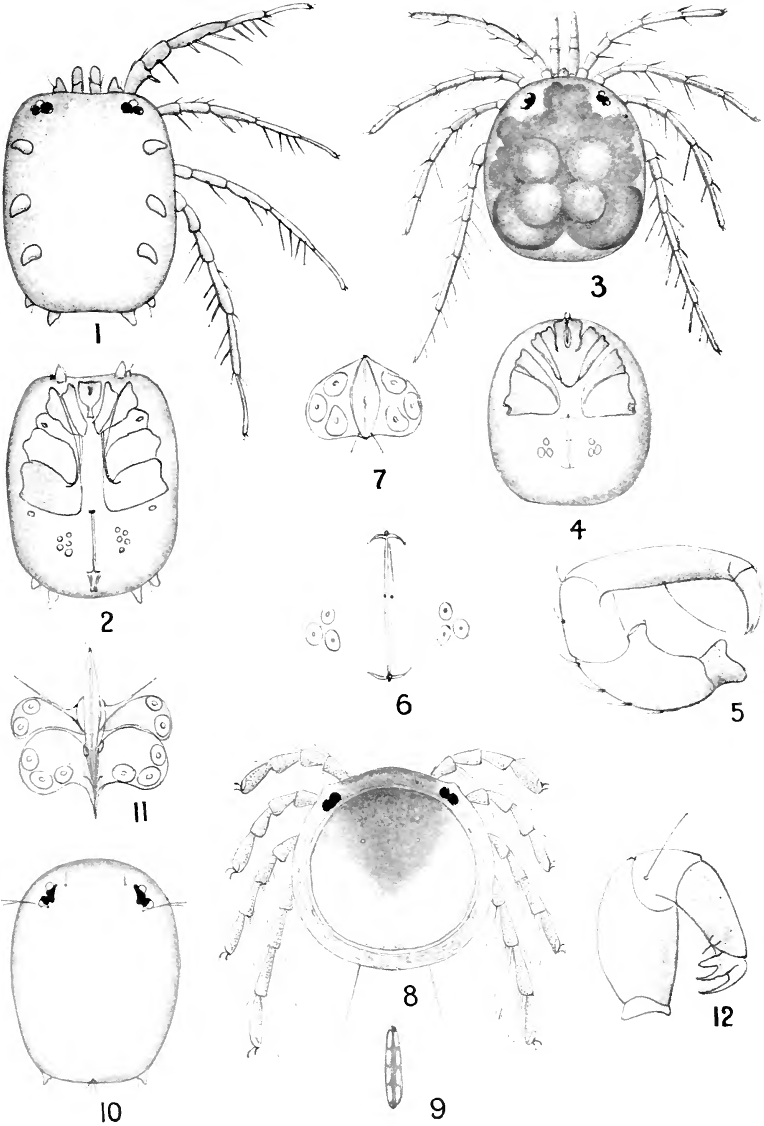
The organism proved to be one of the Oscillatoriae. These are very common and minute plants belonging to the lowest class, the Blue-green Algae or Myxophyceae. I did not find it possible to identify the species, nor could any one to whom it was shown. West mentions the two species named in the report, and Dr. Cooke has one he calls *Lyngbya ochracea*, but the details given are in neither case sufficient to justify a definite statement. The plant consists of filaments formed of a single row of cells about 3·5 μ broad, and usually nearly the same in length. These cells are filled with protoplasm of a yellow-ochre colour during life, and in each there are several highly refractive bodies of various shapes; sometimes these nearly fill the cell, and there is reason to believe that they consist to a considerable extent of sulphur. The filaments readily break up, but when grown without disturbance probably reach a considerable length. They have the usual characteristic movement of the Oscillatoriae. When floating free they bend from side to side and move forward slowly in the direction of their length. The most noticeable feature is the colour, to which I will refer presently. [A sketch of the organism was exhibited, but the highly refractive bodies spoken of are most difficult to represent adequately; they change in figure and in colour with the slightest alteration in focus, but are certainly almost colourless.]

Take now the second case. Early in August I visited "The Welsh Harp" reservoir at Hendon. This is a fairly large piece of water, and of considerable depth. Here, all along the lee shore, the water was turbid, dark green, and without any transparency. With the naked eye one could see floating in it quantities of minute bodies. Where blown by the wind into lines or round floating objects, these bodies were seen to be the cause of the colour. On a subsequent visit, as in the other instance mentioned, these bodies were thrown on the shore in masses, just as small seaweeds and other debris are left by the receding tides. I have never seen duckweed or any of the common algae thrown up by fresh water in such quantities. This condition of things continued longer than in the case of the Totteridge pond, and there was abundance of the organism to be seen late in September; but on a visit in October I could find none along the margin of either part of the reservoir. To my surprise, this organism, when examined under the microscope, proved to be almost identical in size and structure with the other, differing only in colour, which was a bluish green. It had the same refractive bodies, which were equally difficult to observe satisfactorily. Perhaps the filaments varied somewhat more in size than the others, measuring from about 3 to 5 μ. Again I could not identify the species: in no book, to my knowledge, is there a figure or description resembling it. Some living specimens were sent to an authority on algae, and he, with considerable reservation, pronounced it to be *Oscillatoria agardhii*. That still leaves the clay-coloured one to be identified; and on that point I have a theory to offer, but it is not supported by any authority. Practically the only difference between the two is in the colour. The green one, when dried on the side of a glass, is of a bright blue-green; the yellow one scarcely changes its hue at all: there is no indication of the presence of chlorophyll or any of its modifications in it. We may take it, then, that *Oscillatoria agardhii* is a normal plant, able by means of its chlorophyll to fix the carbon dioxide contained in the water, just as any other alga does; while the Totteridge specimen, though probably of the same species, has taken on a saprophytic habit, has lost its chlorophyll, and is able only to derive its nourishment from the organic matter in a state of decay present in its environment. This seems probable, because, while the organism in the large body of comparatively clean water in "The Welsh Harp" reservoir has plenty of light and very little decaying matter at its disposal, the smaller horse-pond at Totteridge is much more shaded by houses, and no doubt, from the use to which it is put, contains a large amount of partially decomposed organic matter, thus favouring the tendency towards a saprophytic habit which some of these lowly organised plants possess. Another detail that seems to point in the same direction is the fact that the green specimens lived much longer and seemed to flourish better in a small aquarium than did the yellow ones, these latter not being supplied, of course, with the impure water which would contain the necessary food. When, however, this suggestion was made to the authority already referred to, he replied that he should not expect the plant ever to become saprophytic. It is most likely that neither of these plants is very common; I have never seen either before. Mr. Hammond, who kindly drew for me "The Welsh Harp" species, had obviously met with it, and had a drawing in his portfolio which exactly agreed with mine.

Of course, in some form they must always be present in the places in which they occasionally appear so abundantly; but the causes which enable them to multiply in this manner seem to be unknown. It cannot be a seasonal increase alone, such as we have in flowering plants, which at the proper time develop and then die away. In that case the "breaking of the meres" would be an annual occurrence, or nearly so, with more tendency to regularity than it seems to have. Clearly there must be some simultaneous occurrence of several favourable circumstances which does not frequently arise: possibly some special type of weather and some narrow range of temperature at a particular season would be features in the required conditions.

Unfortunately I have not, after repeated efforts, found any medium for mounting these algae satisfactorily. The refractive bodies disappear altogether after a longer or shorter time.

[An example of the Totteridge specimen, nearly as in life, was exhibited; also a drawing by Mr. Hammond of the one found at "The Welsh Harp," and drawings by Mr. Akehurst and Mr Burton representing both species.]



C. D. S., *del.*

Hydrachnidae from East African Lakes.

NOTE ON A SLIDING NOSE-PIECE FOR USE IN STEREO-PHOTOMICROGRAPHY.

By A. C. Banfield.

(*Read June* 28*th*, 1910.)

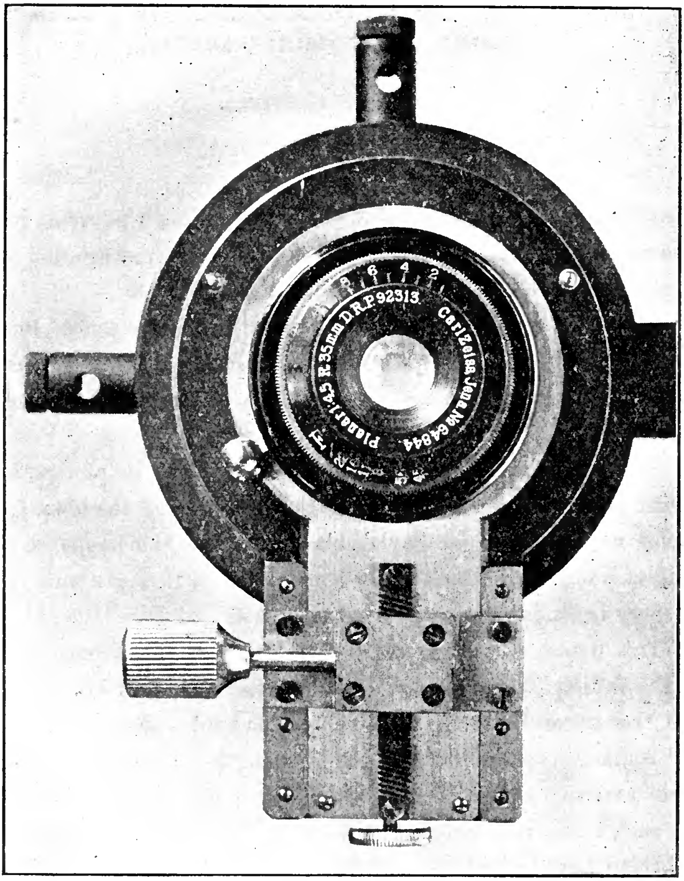
In October last I had the pleasure of reading a paper on low-power stereo-photomicrography and also had on exhibition the apparatus and a few examples of this class of work.

To obtain the results shown then, the object was moved by an amount determined by the magnification and which gave a truly stereoscopic pair of images, at least as far as the object itself was concerned.

Later experiments in this direction with very low powers, and with the object strongly lighted to throw sharp shadows, gave some unpleasantly peculiar results: although the image of the object was perfect, the shadow from it floated in space and gave a very irritating presentment of the whole.

This defect was, of course, due to the altered incidence of the light falling on the object, which is great with very low powers, as the object has to be moved a considerable distance. It is of course impossible to move the illuminating apparatus, condensers and so forth, with the object; the only thing we can do in such a case is to move the objective. To obviate the necessity of this I have had a little piece of apparatus made which fulfils its purpose exceedingly well. It consists of a sliding plate screwed to carry the objective and which is laterally displaceable by means of a small rack and pinion. For several reasons this is more convenient than moving the object, as the illumination is unaltered and the shadows fall in their right place, greatly adding to the beauty of the picture.

I should like to add, however, that this piece of apparatus can be used only on microscopes with a large body-tube; but if any photographically inclined member has a half-plate camera and



his microscope fitted with Zeiss sliding objective-changers, he has all that is necessary for doing high-power stereoscopic work, as the lateral screw with which these changers are fitted is a very efficient means of moving the objective the necessary amount.

NOTICES OF BOOKS.

PHOTOMICROGRAPHS OF MICROSCOPICAL STUDIES. $5\frac{3}{4} \times 8\frac{7}{8}$ in. 62 pages, with 103 illustrations (N.D.). Manchester: Flatters, Milborne & McKechnie, Ltd. Price 2*s.*

Photomicrographs of microscopical studies prepared as lantern slides are unquestionably a very valuable aid in the teaching of botany, for the teacher, by a detailed description of them as they appear upon the screen, is able to make quite clear points that are often very hazy in the minds of his students. Photomicrographs have a greater reality about them than many of the sketches found in the text-books, but they have a great defect as compared with a careful drawing, that of showing one focal plane only. Take, for example, the drawing of the nearly ripe macrosporangium of *Selaginella inaequifolia*, as given in *A Text-book of Botany* (Sachs), and a photomicrograph of the same, and the defect becomes evident.

A photomicrograph, without a very carefully prepared description to accompany it, may cause even greater perplexity to the student than the "crude ideal sketch" it is intended to replace. Many of the plates in the book before us, especially that forming the frontispiece and those of transverse sections of roots and stems, are quite excellent, but their full value is lost to the private student from the fact that there is no full description of them to help him to understand their significance. The extra printing required might add slightly to the cost, but, at the same time, the descriptions would greatly enhance the value of the work.

The method of indicating the various tissues by a horizontal line is not quite satisfactory. Sometimes in indicating a vascular bundle the line ends in a large cell. A V- or bracket-shaped end would be preferable in several cases. The lettering in some instances is quite inadequate, some important tissue being omitted, the endodermis and pericycle scarcely figuring at all in the lettering of stem sections.

The paper and printing are good. It is seldom one gets such clear and large print to explain illustrations. Given the descriptions referred to above, in addition to the present plates, the book would supply a long-felt want. Its range is very wide, covering, as claimed in the preface, the range of study requisite for the student of botany.

R. P.

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the meeting of the Club held on March 22nd, 1910, Mr. C. F. Rousselet, F.R.M.S., Vice-President, in the chair, the minutes of the meeting held on February 22nd were read and confirmed.

Messrs. William Green, C. H. K. Gonville, H. Tomlin, William N. Ellis, William L. Jones and George K. Dunstall were balloted for and duly elected members of the Club.

The list of donations to the Club was read and the thanks of the members were voted to the donors.

The chairman drew attention to the state of the room in which they were meeting. It was the intention of the landlords to reconstruct the building, and when the alterations were completed the Club would probably meet in a room above the present one.

Mr. A. Earland delivered a lecture on "Life on a Scientific Cruiser, and a Visit to a Whaling Station." He briefly described the constitution of the International Fisheries Investigation Commission, which commenced work in 1902, as the result of international conferences held at Stockholm in 1899 and Christiania in 1901. All the countries bordering on the North Sea took part in the conferences, the general scheme of operations being directed by a Central Bureau at Copenhagen. The physical characteristics of the North Sea were then discussed and its extreme shallowness remarked upon. South of a line drawn from Moray Firth to the north point of Denmark, St. Paul's Cathedral, if resting on the sea-bed, would show as an islet of considerable height, as, with few exceptions, the depth does not exceed 50 fathoms (300 ft.), and in many places is only 20 fathoms. The lecturer then described the *Goldseeker*, the cruiser referred to. She was built at Grimsby for the Iceland deep-sea trawling, and measures 118 ft. by 21 ft. beam, and is given as of 200 tons burden. The fittings of the ship put in subsequent to her purchase by the Scottish Fisheries Department were then described.

The "little winch" is a most important piece of apparatus on board. It is placed on the starboard side forward of the bridge and is worked by its own engine direct from the main boiler of the ship. It is used for taking soundings, temperatures, etc., and can haul in cable or sounding-line at the rate of 70 fathoms per minute. Reference was also made to the "big winch" used for heavier work, such as deep-sea trawling, and which carries four miles of warp. Many slides were shown illustrating the methods and instruments employed in the work, including Ekman's current meter, a piece of apparatus very efficient under laboratory tests, but very difficult to use in actual deep-sea work owing to the difficulty of anchoring a ship fore and aft in a rigid position. A specimen of Bidder's deep-sea current bottle, used for determining the direction and velocity of currents in deep water, was exhibited and described. This is an ordinary soda-water bottle loaded with shot, so that its specific gravity is slightly in excess of deep-sea water. It contains a card of instructions bearing a number, which is also marked on the "tally" of the bottle. A piece of fairly stout wire, about 2 ft. long, is fastened to the neck. When thrown overboard at a known position, the bottle sinks to the bottom, where it rests on the point of the wire, which is extended in continuation of the long axis of the bottle, which then drifts with the current. The wire serves to keep the bottle from fouling on the rough surface of the bottom. Many are picked up by trawls or drift ashore; and as finders are requested to return the card to the Fishery Board a fair proportion are traced, and it is now possible to chart with considerable accuracy the movements of the bottom water in the area under investigation. Various forms of surface and mid-water nets were illustrated and described. One, the vertical-haul net, is lowered to any desired depth, and then hauled up, and is supposed to take all organisms in the vertical column of water through which it is raised. Such nets are worked in pairs, one being of coarse canvas and one metre in diameter, intended to catch eggs, young fish, etc.; the other of fine bolting cloth, one foot in diameter, for the purpose of taking microscopic *plankton.* Another piece of apparatus, the Buchanan-Petterson water-bottle, takes a sample of water at any required depth, recording at the same time the temperature at that depth. Beam-trawls and otter-trawls were then illustrated and described, and the methods of handling referred to. The advantages of the otter-trawl, introduced about fifteen years ago, were pointed out. The size of a beam-trawl is limited by the length of the boat; the length of the beam cannot exceed the length of the boat, and in practice a 60-foot beam is the limit of safety and efficiency. In the otter-trawl the mouth is kept open, not by a beam, as in the first case, but by the action of two large boards, one attached to each side of the mouth, vertically, in such a manner that they diverge when the net is dragged through the water. The otter-trawl can be worked with efficiency up to a width of 150 to 180 feet across the mouth, thus trebling the fishing area of the net as compared with the beam-trawl, and moreover it can be used in deeper water than the latter. The trawls are used on the *Goldseeker* for the purpose of counting, measuring, sexing, and in some cases marking, the fish caught. A fish selected to be marked is taken as quickly as possible after the trawl comes in, is placed on a board, measured, and a numbered button is fixed with silver wire through a part of the body where it will not hurt or inconvenience the fish, and, a record having been completed, it is thrown overboard, with an average lapse of about three-quarters of a minute after first leaving the water. As the button is worth 2*s.* 6*d.* in the form of a reward paid to the finder when the fish is caught in the ordinary way, a large number of these are recovered, and show that the average migration of flat fish (only such, as a rule, are marked) does not usually exceed 60 miles.

Subsequently the lecturer passed to his personal experiences on board the *Goldseeker* during several voyages of the ship, and showed many photographs illustrating the çoast and sea life around the Orkneys and Shetlands. From the Shetlands the cruise was extended to the lonely and little-visited Faröe Islands, on the outer fringe of Europe, a number of views, illustrating their grand scenery and interesting inhabitants, being thrown on the screen. Mr. Earland then went on to describe the methods adopted in the whale "fisheries," one of the chief industries of the Faröe Islands, which also furnishes the staple food of the islanders during winter. The particular whale hunted is the grindhval, or pilot whale (*Globicephalus melas*), known in Shetland as the "caa'ing whale," or "black fish." This is one of the toothed whales, and has a maximum length of about 22 ft. It gathers in schools of about 600 in number. Each whale yields about 30 gallons of oil, worth about £2 10*s.*, and the flesh is valued at about £1 5*s.* The flesh is cut into slabs and salted, or into strips, which are hung up under the eaves of the houses to dry. The meat is said to be palatable. Mr. Earland then passed to his impressions of a visit to one of the whaling stations established in Shetland during recent years by the Norwegians, and gave a short historical account of the whale-fishing. It was stated that until recently the rorqual and humpback whales enjoyed immunity from attack, owing to their speed and agility, and their savageness when attacked with the harpoon rendered their capture by boats almost impossible. In 1870, however, a Norwegian, Sven Foyn, invented the harpoon-gun, which has revolutionised the industry, and will, in all probability, exterminate the remaining whales within a comparatively short period of time. The harpoon-gun is a steel carronade about 4 ft. long and with a 3¼-in. bore. The harpoon itself weighs about a hundredweight, and carries at its point an iron cone containing a charge of powder, which is exploded by a friction-fuse when the barbs are buried in the whale. A successful shot means almost instant death to the largest whale. The carcase is drawn alongside the ship and secured to the bows by a chain round the flukes of the tail. It is then pumped up with air like a bicycle tyre to increase its buoyancy, and is towed to a "station" and there cut up. First the blubber is stripped off, then the head is separated from the body, the baleen removed, and the head and skull cut up by a steam-saw. The best portions of the flesh are removed for food, and sold on the Continent as whale-beef. The residue of flesh, bones, etc., after all oil has been extracted, is kiln-dried and ground down to a powder, which is sold as whale-guano, a splendid fertiliser. Sibbald's rorqual (*Balaenoptera Sibbaldi*) is the largest animal known to science, either in the recent or fossil state. In 1909 no less than 30 specimens were taken into the whaling station at Bunaveneader, in Harris. The bulls averaged 72 ft. 9 in. in length, and the cows 68 ft. 2 in. The largest bull was 85 ft. long, and the largest cow, which was 81 ft. long, had a girth of 46 ft. The species occurs of even larger size than this, and is reported to attain a length of 120 ft. in the Antarctic. For the purpose of comparison, Mr. Earland said that just before the meeting he had measured the length of the room in which members were sitting. He found it to be 73 ft., so that some idea of the enormous size frequently attained by individuals of these species could be formed. As a result of the observations and records of the whaling stations which had now been kept for some years by Mr. Haldane, of Ollaberry, Shetland, our knowledge of the whales had been enormously extended. Several species which were formerly regarded as very rare were now known to be abundant at certain times of the year and to be subject to migrations which for extent could only be compared with those of some birds. They seemed to follow a circular route in which, appearing in early spring on the Atlantic coasts of Ireland, they gradually worked northwards by way of Shetland and the Norway coast to the Arctic seas. Then by way of Iceland to the western Atlantic, where, following the coast-line southwards, they wintered in Bermudan and tropical waters, to reappear again in the following spring on the Irish coast.

After some remarks by Mr. Heron-Allen, a hearty vote of thanks was accorded to Mr. Earland for his very interesting paper. Mr. Earland, briefly replying, said he was much indebted to Messrs. H. F. Angus & Co. for the loan of the numerous microscopes under which many of the forms he described were exhibited.

At the meeting of the Club held on April 26th, 1910, Prof. E. A. Minchin, M.A., F.Z.S., President, in the chair, the minutes of the meeting held on March 22nd were read and confirmed.

Messrs. William J. Lawrence, George F. Jones, E. W. Parfitt, the Hon. William H. Lascelles, the Rev. E. Jervis and L. F. Hammond were ballcted for and duly elected members of the Club.

The list of donations to the Club was read and the thanks of the members were voted to the donors.

The Hon. Secretary read the following announcement:

Prof. James W. H. Trail, M.A., M.D., F.R.S., has presented to the Linnean Society a sum of money for the purpose of encouraging the study of protoplasm. An award will be made about once in every five years for original work bearing directly, or indirectly, upon the "physical basis of life." With the award the Linnean Society will present a bronze medal, bearing on the obverse a portrait of Linnaeus, and on the reverse the words "Trail award" and the name of the recipient in a wreath. The first presentation will be made at the forthcoming Anniversary Meeting of the Linnean Society, and it gives us great pleasure to announce that the first recipient of this award is our President, Prof. E. A. Minchin.

The Hon. Secretary said that with the death of Edward Percival Wright one of the links, connecting the old school of naturalists with the modern students of biology, was severed. Prof. Wright was born in Dublin, 1834. During the twelve years succeeding his matriculation in 1854, he published a series of papers on the fauna and flora of the S. and W. coasts of Ireland. In 1858 Wright was appointed lecturer in zoology and Director of the National History Museum of Trinity College. In 1866 he published in conjunction with T. H. Huxley an account of the fossil vertebrates from the Jarrow Colliery. In 1867 Wright went to the Seychelles Islands, bringing back an important collection of animals and plants. Shortly after his return he was appointed to the chair of botany at Trinity College, and held that position until he resigned in 1904. He arranged and indexed the valuable series of plants belonging to the College. In conjunction with M. Studer he reported on the Alcyonaria of the Challenger expedition.

It may interest members of the Q.M.C. to know that Prof. Wright, although not a member of the Club, was one of the founders of the Dublin Microscopical Club, and in this he was associated with Mr. Archer, whose researches are well known to some of our members. Having met for some time informally, this Club appears to have received a proper constitution and rules in Dec. 1860, five years before the origin of our Club.

Mr. C. Lees Curties presented to the Club twelve dissections and preparations of insects mounted by the late Mr. Frederick Fitch, who joined the Club in 1867. The presentation was accompanied by a cabinet portrait of Mr. Fitch, who had been well known to the older members of the Club. The thanks of the Club were voted to Mr. Curties for these gifts.

Mr. A. E. Hilton read a paper on "The Life-phases of Mycetozoa."

The thanks of the Club were unanimously voted to Mr. Hilton for his paper.

Mr. James Burton read a note on "Two Instances of 'Breaking of the Meres.'"

Some discussion followed, in which the Hon. Secretary and Messrs. Paulson, Offord, Pearson, and R. Inwards took part, and to which Mr. Burton replied.

Mr. Burton also called attention to an organism found in a collection made during the excursion of the Club on the previous Saturday, mostly on the rootlets of duckweed, but also on the submerged leaves of the water ranunculus. The description was aided by drawings on the board showing how the first form broke up into eight gonidia, and subsequently again produced eight more, forming a very pretty object under the microscope. It was understood to be *Sciadium Arbuscula.*

At the meeting of the Club held at the Morley Hall, George Street, Hanover Square, W., on May 24th, 1910, Prof. E. A. Minchin, M.A., F.Z.S., President, in the chair, the minutes of the meeting held on April 26th were read and confirmed.

Messrs. James Grundy, Charles Taylor, William N. Allen, Henry J. Troughton, F. G. Carruthers and E. G. Brown were balloted for and duly elected members of the Club.

The list of donations to the Club was read and the thanks of the members were voted to the donors.

The Hon. Secretary (Mr. W. B. Stokes) read a note on, and exhibited a specimen of, a micrometer designed in 1878 by Professor Burch, of Enfield College. He said it consisted of a short length of tube fitting over the eye-piece. This tube is cut at an angle of 45 degrees to the optical axis, and across this is placed a piece of plate-glass silvered on the outside. This has at its centre a perforation smaller than the diameter of the pupil of the eye—in this respect similar, but prior, to Abbé's drawing apparatus. A rod is attached at right angles to the fitting. Sliding on this rod, and at right angles to it, is a scale which may be divided to any convenient number of small divisions. The instrument exhibited had an ivory scale 15 cm. long, divided to millimetres. In use, a stage micrometer is placed on the microscope stage. The eye, placed close to the perforation in the silvered mirror, observes the divisions of the stage micrometer superimposed on the divisions of the sliding scale referred to.

The scale is then slid along the rod until a division of the stage micrometer corresponds (for convenience) with an even number of divisions on the scale. This is noted, and the object to be measured is placed on the microscope stage. Its real size is at once deducible from the number of divisions, of which the value is known, that its image is observed to occupy on the ivory scale. The rod carrying the scale being divided, it is only once necessary to ascertain for each combination of objective, eye-piece and varying tube-length employed, the position on the rod that the scale is to occupy, to have a most convenient and efficient form of measuring instrument.

Mr. Stokes also referred to the convenient method of using squared paper for the purpose of finding intermediate values of magnification with varying tube-lengths, when only two or more values, with the same combination of objective and eye-piece, but with differing tube-length, are known. Examples were given.

Mr. C. Lees Curties, for Mr. C. Baker, exhibited a number of preparations of crustacea injurious to wooden piers and piles. Four of the preparations were of amphipods and five of isopods, of which latter were included specimens of the very rare *Leptochelia sairgnii* and *Arcturus* sp. There was also shown a specimen of the exceedingly rare *Sphaerosyllis hystrix*, carrying embryos. Very little is known of the development of this form. It is illustrated in McIntosh's *Worms*, the last volume of the Publications (4to) of the Ray Society.

The thanks of the meeting were accorded to Mr. Lees Curties for his interesting exhibit.

Mr. A. E. Hilton exhibited a preparation of the Mycetozoon *Spumaria alba* (Aethalium) × 20, and Mr. A. Earland showed living *Difflugia* sp.

At the meeting of the Club held on June 28th, 1910, at the Doré Gallery, New Bond Street, Mr. C. F. Rousselet, F.R.M.S., Vice-President, in the chair, the minutes of the meeting held on March 24th were read and confirmed.

Mr. Alfred E. Charlton was balloted for and duly elected a member of the Club.

The list of donations to the club was read and the thanks of the members were voted to the donors.

The Hon. Secretary said they would regret to hear of the death of Mr. J. W. Goodinge, which took place on June 18th. Mr. Goodinge joined the Club in 1872; he at one time served on the Committee, and had taken great interest in the social side of the Club.

Mr. Banfield exhibited and described a sliding nose-piece for use in stereo-photomicrography, by use of which in low-power work better results could be obtained than by moving the object itself. Transparencies were exhibited showing the advantages of the new method.

Mr. D. Bryce read a paper on "A New Classification of the Bdelloid Rotifera." The paper commenced with a review of the systems and proposals of previous writers. The Bdelloid Rotifera were first recognised as a separate group by Ehrenberg, who in 1830 associated nine species in the section Philodinaea in his earliest classified list of micro-organisms. In this classification, and in the more comprehensive systems published by him in 1831 and 1838, such of the genera as have since proved to be recognisable were distinguished mainly by the possession of eyes, and, when they were present, by their position. Thus the eyes were placed in the front of the head in the genera *Rotifer* and *Actinurus*, but in the neck in *Philodina*, whilst the genus *Callidina* had none. The accuracy of these apparently simple characteristics was first effectively challenged by Milne, who, in 1886, proposed to discard the use of the eyes in the distinction of the genera of the Philodinaea. Reference was made to the additional genera and families added by Hudson and Gosse and others, to the criticisms of Janson, and to the discoveries and proposals of James Murray.

In the classification now formulated the author accepts the position assigned to the Bdelloida by Plate and by Wesenberg Lund as constituting an order of the Digononta, or two-ovaried Rotifera. The genera are divided into three families—the Adinetidae, which have an imperfect rostrum, cannot creep about without the use of the corona, and which cannot swim; the Philodinidae, whose rostrum is well developed, which can creep about when the corona is withdrawn, and can swim at will when it is displayed; and the Microdinidae, in which the rostrum is well developed, but the corona practically absent. The Microdinidae consists of a single genus, represented as yet by one species only. The Adinetidae include two genera which differ very notably in the structure of the foot. The Philodinidae are represented by thirteen genera, including at least nine-tenths of the Bdelloida known at this time. To reduce this unwieldy crowd of species into order it has been necessary to bring into use details hitherto unemployed for generic distinction. With few exceptions, the great majority of the species conform very closely to one structural plan. One particular deviation from uniformity has been considered of high importance. It is found that the proportion of the lumen, or inner cavity of the stomach, varies from the normal type in certain species which are otherwise closely related, and which have the common characteristic (but characteristic of them only) of moulding the food into pellets. In these species the lumen of the stomach is nearly as great as the whole diameter of the organ, whereas in the normal type of stomach the lumen is relatively narrow. The Philodinidae are thus separated into two sections, with wide and narrow lumen respectively. In the author's opinion, the species with the wide lumen, about one-fourth of the family, represent an earlier stage in the evolution of the family type than that indicated by the species with a narrow lumen. In this section are three genera.

The species which have the lumen narrow divide naturally into three sub-sections: (1) with four toes; (2) with three toes; (3) with toes bearing a number of cup-like suckers, or united to form a broad disc or twin discs. The four-toed species are considered to be the most highly developed of the Bdelloida, and are divided into five genera, including the veteran genus *Philodina* under amended definition. The species with three toes are represented by two old genera, *Rotifer* and *Callidina*, also under amended definitions. The third sub-section contains species relatively few in number, but mostly of large size, which have been distributed among three genera.

The chairman, Mr. C. F. Rousselet, said that the Bdelloid rotifers were quite a specialist's study. He had found them so intricate that he now left them alone. Mr. Bryce had made a special study of this particular group, and there was no one better able to revise the classification than he.

Mr. James Murray said that Mr. Bryce's paper was possibly of greater interest to him (Mr. Murray) than to any one else in the world. Nearly everybody has fought shy of the Bdelloids; certainly no one else has taken a grasp of the whole group. One reason, perhaps, is that it is sometimes necessary to watch for hours, and sometimes even weeks, to see Bdelloids feed; and it is rarely possible for amateurs to expend so much time for this purpose. Hitherto there was no real classification of this group. That adopted from Ehrenberg's to the present time is purely artificial. He had been urgently clamouring for this classification for some years. The most important of all the groups distinguished by Mr. Bryce was the "pellet-makers." The differences between these and other Philodinidae are so radical as to be possibly even family distinctions. It had been objected that when one ceases to make use of the eye-spots it is very difficult to identify the species, but he did not think the objection valid. If it were required to make use of the eye-spots, it would be possible to use an artificial key. He was very thankful that the new classification was an accomplished fact.

The Hon. Secretary read a paper by Mr. E. M. Nelson, F.R.M.S., on "*Navicula rhomboides* and Allied Forms." In the paper the author referred to the old controversy as to the identity of the Amician test, and gave quotations from writings dated 1850 to 1855 to show that it was not *Navicula rhomboides*, and agreed with Dr. Karop, who, in a paper read before this Club, March 15th, 1895 (*Journ. Q.M.C.*, Vol. VI., p. 75), expressed the opinion that Prof. Amici had no one particular test in mind, and that the test as known in America differed from that used here. He (Mr. Nelson) suggested the use of a numerical ratio by which the validity of doubtful ascriptions might be tested.

A cordial vote of thanks was accorded Mr. Nelson for his interesting paper.

Mr. A. Earland gave an address on "Arctic Types of Foraminifera in the North Sea." Geologically, the North Sea, as it now exists, is of quite recent origin. Until very late Tertiary times there was no connection with the warm Atlantic by way of the English Channel. The North Sea was then an Arctic sea. From an examination of the Foraminifera dredged by the s.s. *Goldseeker*, some Arctic types were shown to be now surviving under changed conditions, and that an immigration of warm-water forms had taken place since the removal of the land-barriers. Mr. Earland said that all the evidence derived from the rhizopodal fauna tended to confirm the geological theory.

The paper will be published in the Report of the International North Sea Commission (Scotland).

After a few remarks by Mr. Heron Allen, the thanks of the meeting were heartily voted to Mr Earland for his interesting and suggestive paper.

Mr. Earland in responding expressed his thanks to Messrs. H. F. Angus & Co. for the loan of the microscopes under which the specimens illustrating his paper had been exhibited.

GOSSIP NIGHT.

Objects Exhibited and Notes.

(*July 26th*, 1910.)

A. E. Hilton: Sporangia of *Arcyria punicea*, × 20, showing the elastic network of the expanded capillitia, after dispersion of the spores. Part of a gathering found among moss. The sporangia had formed partly on the moss and partly on the sandy surface of the mould in which the moss was growing.

(*August 9th*, 1910.)

A. E. Hilton: *Lamproderma arcyrionema*, × 20. The brilliant sporangium walls are membranous and evanescent, and fall away in large fragments. A portion sometimes persists as a collar round the base of the sporangium. Found among moss, on sandy and matted soil.

(*September 13th*, 1910.)

A. E. Hilton: Sporangia of *Badhamia foliicola*, × 20. These were formed by the revived sclerotium of a plasmodium, which had crept up a hop-pole and dried there. In *B. foliicola* there is less lime than in *B. utricularis*, and the specific characters vary accordingly; whether this justifies uniting the species is doubtful.

(*September 27th*, 1910.)

A. E. Hilton: Capillitia of *Arcyria flava*, × 20. While enclosed within the sporangium wall the fibres of the capillitium are bent and folded in every direction; when the sporangium dries after maturing, the fibres straighten and stiffen, so that the meshes of the network become larger; the capillitium expands to a remarkable length and the spores are scattered.

(*October* 11*th*, 1910.)

A. E. Hilton: Aethalium of *Spumaria alba*, × 20. The plasmodium of this species is heavily charged with calcium carbonate. It creeps up grass stems, and forms an aethalium three or four inches above the ground. In the process of spore-formation the plasm is purified from lime, and condenses into branched and lobular masses of spores; the whole of the lime is deposited outside as a thick crust of white crystals. From the specimen exhibited the lime has been removed to show the lobular formation of the confluent sporangia.

EXCURSIONS, 1910.

ROYAL BOTANIC GARDENS, REGENT'S PARK.

On Saturday, April 2nd, the Club commenced its excursion season by visiting—as for many years past—the Royal Botanic Gardens, Regent's Park. The weather was beautifully spring-like, and thirty-eight members attended, including several who have recently joined. Pond-life was scarcely so forward as usual, notwithstanding the mild winter, and, as is to be expected after so many annual visits, the captures are liable to partake rather of the character of old friends than of novelties; but of these latter there were plenty. One visitor has recorded species of *Floscularia*, *Stephanoceros*, and *Melicerta*, besides a large number of less-noted organisms, and "a host of rotifers." A small branch was taken from the water which bore a great quantity of the fresh-water sponge—Spongilla. A *Closterium* and a *Cosmarium* among the desmids were found. In the *Victoria regia* house several fine banana trees were noticed, one bearing a huge bunch of nearly ripe fruit. In the economic plants house the large *Monstera* showed one inflorescence at its best, besides several others. Its resemblance to that of the miscalled "arum lily" and our native cuckoo-pint was noticed, these plants, though so different in size and appearance, being members of the same natural order. In the conservatory a Brazilian coffee shrub with a good crop of berries, and some fine specimens of *Amaryllis* in full flower, were on show.

WOOD STREET TO HIGHAM'S PARK, EPPING FOREST.

The excursion on April 23rd, to Wood Street, Epping Forest, was favoured by fair though somewhat chilly weather. There was a good attendance of members, who were conducted by Mr. Wilson, and had the pleasure of the company of Mr

Murray, the biologist of Sir E. Shackleton's Antarctic expedition. The results were extremely good. It would be impossible to give a tithe of the acquisitions in pond-life, but a few may be noted. One member records *Zoothamnium*, *Acineta*, *Daphnia magna*, and *Actinosphaerium*, "besides a host of smaller fry." Entomostraca and free-swimming rotifera were extremely abundant, also *Melicerta* in beautiful condition. A number of the peculiar and interesting rat-tailed maggot, the larva of *Eristalix*, was found, and also the well-known phantom larva *Corethra*. In the algae, *Oedogonium*, *Mougeotia*, and *Batrachospermum*, also *Nitella*, bearing its interesting reproductive organs, were taken. The very pretty, but perhaps little-known, *Sciadium Arbuscula* was in extraordinary abundance on the leaves of the water-crowfoot. *Synura uvella* and *Dinobryon sertularia* were noticed. These, now classed with algae, were formerly considered animals—an opinion which many microscopists probably retain. Among other aquatic flowering plants, *Hottonia palustris* and *Utricularia* occurred. *Adoxa moschatellina* was found—a somewhat singular plant belonging to the same order as the common ivy, but quite unlike it in habit, which had the additional charm, for some, of being covered with the fungus *Puccinia adoxae*. Twenty members stayed to a substantial tea at Higham's Park before returning to town.

HANWELL (May 7th).

BURNHAM BEECHES.

On May 28th the excursion of the Club was to Burnham Beeches. There was a good muster, and the members were favoured with fine weather. The walk from the station was very enjoyable, the hedges and trees being in their early summer perfection. White bryony was noticed in several places, though not yet in flower; the evening and bladder campions were plentiful, the latter yielding instances of its anthers being attacked by the fungus *Ustilago antherarum*. The three lakes at the Beeches were visited, and gave abundant material for future examination. A singular fact (in the writer's experience) was the entire absence of the Entomostraca, not even a cyclops being seen, a dead

Canthocampus and some indistinct remains which were taken from a bladder of *Utricularia* being the only specimens of the class met with. On the other hand, free-swimming Rotifera were extremely plentiful, both in numbers and species, the large and beautiful *Actinurus neptunius* being most in evidence, while *Brachionus bakeri* and *palea*, *Asplanchna priodonta*, and (I think) *Stephanops muticus* were also identified, besides numbers of smaller species. A noticeable feature was the presence in great quantity of the smaller algae. *Scenedesmus* and *Ankistrodesmus*, in many species and varieties, as also *Pediastrum*, were abundant. The Desmidiaceae were well represented, two filamentous forms—*Sphaerozosma*—being particularly noticeable. *Bulbochaete* was recognised. After tea in the garden at Grenville Lodge, the station was reached for the return in time to avoid a threatened storm.

OXSHOTT.

On June 11th the excursion to Oxshott was scarcely so successful as usual. There was a fair attendance; but, unfortunately, none of the members were well acquainted with the route, which was through the pine woods of Esher Common. The outing was therefore more productive of pedestrian exercise than of the usual and desired results. In the woods *Pellia epiphylla* was seen on the sides of small ditches; many species of mosses in fruit, and *Polytrichum* bearing male "flowers." Lichens, of course, were plentiful, and several members hoped they had acquired Mycetozoa. *Sphagnum acutifolia* and *obtusifolia* were in plenty. The Cotton-grass (*Eriophorum*) was noticed near the Black Pond. Several of the excursionists became acquainted with the large wood-ant, *Formica rufa* (?) known locally as an "emmet." These are very numerous among the pine-needles on the ground, and are famous for their insinuating ways and spiteful disposition. A male stag-beetle was caught. On a bank was found a somewhat uncommon plant, *Claytonia perfoliata*, belonging to the small order the Portulaceae. It is not indigenous, but is a garden escape, having been brought as a culinary herb from N.W. America. The pond-life captures were poor, as would be expected in the circumstances. On a roadside pond there was a quantity of bluish scum, which proved to be *Oscillatoria tenuis.* Plants of this genus grow in a sheet on the mud at the bottom of ponds, then under the influence of light they produce bubbles of gas, which, being entangled among the filaments, float the mass to the surface. On the mud of a partly dried ditch, *Anabaena* was taken, and several species (or varieties) of the common *Euglena.* Tea was obtained at Oxshott before the return to town.

NORTHWOOD.

The excursion on June 25th to Northwood was quite spoiled by the weather. On leaving the station it seemed hopeful and there was even a gleam of sun; but after a short time had been spent at the first pond, clouds came up, and shelter had to be taken under a hedge from a tremendous downpour and heavy thunderstorm. After about half an hour of this the majority decided it was useless to go on, and most of the party returned to Northwood for town.

CHINGFORD (July 9th).

RICHMOND PARK.

The excursion to Richmond Park on Saturday, July 23rd, was favoured with fine weather, and there was a fair attendance of members. Samples were taken from the pond at Ham Gate, from the larger of the Pen ponds, the Leg of Mutton, and Round ponds. There was plenty of microscopic life, but the chief feature seemed to be the extreme abundance of *Stephanoceros eichhornii*, *Floscularia ornata*, *F. campanulata*, and *Œcistes.* These, as is commonly the case, were chiefly found on *Myriophyllum.* Perhaps owing to the beauty and interest of these grander examples of microscopic life, no record was taken of more ordinary organisms. It was noticed, however, that the water in a quiet corner was rendered green by the presence of *Microcystis*, an exceedingly minute plant that sometimes exists in such quantities as to be obvious. Tea was obtained at one of the hotels in Richmond, and the return to town was, owing to the beautiful evening, reluctantly made.

HIGHAM'S PARK.

At the special pond-life excursion to Higham's Park, on August 20th, there was a good attendance of members, two of them being accompanied by welcome friends who were interested in the subject. The weather was, as usual this summer, not quite all that could be desired; but this shortcoming was amply compensated by the richness of the captures. The following list (by no means exhaustive) was furnished by one member: In Algae: *Zygnema* (in conjugation), *Closterium* sp., *Oedogonium* sp. In Protozoa: *Arcella vulgata*, *Difflugia* sp., *Stylonychia mytilus*; *Vorticella nebulifera*, *Zoothamnium arbuscula*, *Vaginicola*, *Stentor mülleri*. In Rotifera: *Conochilus volvox*, *Brachionus bakeri*, *Stephanoceros eichhornii*. In Entomostraca: *Alona costata*, *Bosmina cornuta*, *Canthocampus minutus*, *Ceriodaphnia reticulata*, *Chydorus sphericus*, *Graptoleberis testudinaria*, *Peracantha truncata*, *Simocephalus vetulus*, *Scaphioberis mucronata*. In Diptera: *Tanypus maculata* (larva). In Neuroptera: *Ephemera vulgata* (larva). In Polyzoa: *Fredericella sultana* and *Plumatella repens*. This last was in great abundance and fine condition. Plenty of water-mites also were present, but only two species, *Unionicula aculeata* and *Neumania spinipes*, were represented. One member ended his list of acquirements with "a fully stocked museum and aquarium," which is both comprehensive and satisfactory, and in accordance with the experience of most of the visitors.

TOTTERIDGE (September 3rd).

EAST LONDON WATERWORKS.

The excursion on Saturday, September 17th, was to the East London Waterworks. By the kindness of the authorities a very pleasant afternoon was spent at pond work. The chief desire seemed to be to acquire *Cristatella*, and an abundance of this interesting polyzoon was met with. The statoblasts were in such quantity in a quiet corner of one of the streams that they almost blackened the net, and it was no easy matter to get rid of them as they clung to the fabric with their numerous grapnels. Some long grass-stems growing in a deep stream near the entrance were covered so thickly with diatoms as to be invisible themselves, and presented an elegant object as the festoons and masses gently swayed and bent in the slowly running water. The diatoms proved to be *Fragillaria*, probably *capucina*, a not very interesting species, being almost without markings; the only advantage possessed being that it was an opportunity for obtaining an almost unmixed gathering of a filamentous species. A fine *Oscillatoria* growing on the bottom close by was most likely *O. frolichii.*

Plumatella was taken in abundance, as were water-mites, and, of course, many species of Entomostraca, and larvae of Diptera. Fresh-water sponge was in masses on the brickwork of a bridge, while tiny specimens occurred frequently on the water-lily leaves and petioles. Chara in fruit was found. Rotifera were taken in considerable numbers; the species have not so far been reported. It was a fine afternoon, and the twenty-four members present were quite satisfied with the results.

SURREY COMMERCIAL DOCKS (October 1st).

OBITUARY NOTICE.

WALTER FRANCIS FREDERICK WESCHE.

Born 1857; *died* 1910.

It is with great regret we have to record the death of Mr. Wesché, which took place on September 26th after some months of illness. Mr. Wesché was born in 1857, at Colombo, Ceylon. At an early age he came to England and studied the pianoforte under Mr. Oscar Beringer, and composition under the late Berthold Tours and Dr. F. H. Cowen. He taught harmony at the Oscar Beringer School for the Higher Development of Pianoforte-playing, and the pianoforte at the Royal Normal College for the Blind. In addition, Mr. Wesché had held organ appointments at St. Thomas's, Westbourne Grove, and St. Stephen's, South Hampstead. As a composer he had achieved recognition in the musical world, and of his works mention may be made of the "Legend of Excalibur," which was played at the Crystal Palace, an orchestral suite which gained the prize offered by the Westminster Orchestral Society. His overture in A minor, "A Lost Cause: Scotland, 1745," gained one of the prizes offered by the Musicians' Company in their competition for wind instrumental music. He was an Associate of the Philharmonic Society.

When free from professional duties he devoted his time to scientific research, paying particular attention to the anatomy of the Diptera, on which subject he became an authority. Mr. Wesché joined the Q.M.C. in 1901, and was elected a Fellow of the R.M.S. in the same year: at the time of his death he was serving on the Council of the R.M.S. and the Committee of the Q.M.C. He contributed a number of papers to the Journals of both societies—twelve in all to the *Journal Q.M.C.* He also contributed important papers to the Linnean Society.* His last scientific work was done for the Entomological Research Committee, and was published in the *Bulletin*.†

He will be greatly missed by his many friends, for he was a regular attendant at our ordinary meetings as well as on "gossip" nights.

---

* (1) "The Labial and Maxillary Palpi in Diptera," *Trans. Linn. Soc.*, ser. 2, Zool., vol. ix. (1904), pp. 219–30, pls. 8–10.

(2) "The Genitalia of both the Sexes in Diptera, and their Relation to the Armature of the Mouth," *l.c.* (1906), pp. 339–86, pls. 23–30.

† "On the Larval and Pupal Stages of West African Culicidae" (based on material collected by Dr. W. M. Graham at Lagos, West Africa), *Bulletin of Entomological Research*, vol. i., pp. 7–50, pls. 1–7, pub. April 1910.

HYMENOLEPIS UPSILON, A NEW SPECIES OF AVIAN TAPE-WORM.

By T. B. Rosseter, F.R.M.S.

(*Read November 22nd,* 1910.)

Plate 6.

This pretty little worm was found by me last January parasitic amongst the faeces of the intestine of a wild duck—*Anas boschas.* Out of the number of wild ducks and other Natatores whose intestines I have examined this is the only instance in which I have found it, and in this case they were very few in number. Before describing this minute tape-worm, and with a view to its identity, as the hooks on the scolex closely resemble those of *Taenia microsoma,* it were better that I gave a condensed account from Krabbe of the history of that worm: *Taenia microsoma* was discovered by Schilling in Greenland in 1823, who found it abundantly parasitic in the intestine of *Anas mollissima.* He submitted his specimens to Creplin, who, in *Novae observationes de Entozois Berolina,* 1829, reported on them under the name *Taenia microsoma.* Krabbe merely says that the genital pores were unilateral and that the small head was *hookless.* Dujardin, *Hist. des Helminths,* p. 610, No. 132, supplies us with a little more information respecting Schilling's worm, and says that "Creplin's specimens were very young, only 7–13 mm. in length, as thin or thinner than a piece of fine thread; the cirrus was cylindrical, almost claviform. The form of the head was variable; suckers large; proboscis or rostellum elongate-claviform; the neck and all the segments were very short." To return to Krabbe: H. A. Pagenstecher (*Beitrag zur kenntniss der Geschlechts-organe der Tanien in Zeit. für wissenschaftliche Zoölogie,* 9ter Bd., Leipzig, 1858), states that he found small worms, consisting of 21 segments, parasitic in *Anas boschas.* The rostellum bore *ten* small hooks; the genital pores were unilateral; the cirrus hirsute; the terminal segments contained unripe eggs. They did not attain their maturity in the strobila, but the segments burst and emptied themselves into the intestine of the host, for in the intestine of the same bird he had found them collected together in strings which he compared with *slugs' egg-masses*—"*hvilke han sammenligner med Sneglenes Aeggemasser*"; and as the eggs contained "Fosterkroge"—that is, embryonic hooks—he, Pagenstecher, assumed that they were the product of the bursting of the separated terminal segments of his worm, and he almost believed that his specimen *might* be referred to *T. microsoma.*

In the University Museum (Copenhagen) besides Creplin's specimens there are some specimens of tape-worms collected in Greenland by Pfaff and Olrik, who found them in large numbers in the intestine of *Anas mollissima* and on one occasion in *Anas spectabilis.* The majority of them were 12 mm. in length, and 0·5 mm. in breadth; there were some that were 40 mm. long, but then they were in a very loose, flabby (*sluppet*) condition. The rostellum was long, slender, claviform, and on the knob there were, according to Krabbe, "*ten* hooks whose length varied according to the different species of eider-duck they were taken from, viz. 0·037–0·061 mm. (Fig. 4*a–c*); yet there was no mistaking, in spite of the difference in size, that they belonged to one and the same species of tape-worm. Segmentation commences close behind the head. The number of segments was seldom more than from 150–180; now and then, but this was rare, there were as many as 500 [this must have been in the 40 mm. worm] in the strobila. I never at any time met with a specimen with so small a number of segments as Pagenstecher gives, although in the remaining essentials they agree with his description. The genital apertures were unilateral. The cirrus was 0·084 mm. long, frequently extruded, thickened at its point, in some instances covered with bristles, or small thorns, at other times destitute of these, they having possibly fallen off during maceration after death. The last segments generally contained unripe eggs; there were, however, individual specimens with fully developed eggs [no doubt the 40 mm. specimen with 500 segments], and when these were crushed by pressure, they were squeezed out in the form of a wreath in a similar manner to that Pagenstecher has described with his specimen."

Krabbe says that he himself took tape-worms from *Anas fusca* and *marila* that he was unable to distinguish from the above, but that in November 1867 he found them in large numbers in *Anas fusca.* They were only 2 mm. long; there were as many as 60 segments in the strobila, 0·3 mm. in breadth. There were *ten* hooks on the rostellum, 0·043 mm. long (Fig. 4*d*); the genital apertures were unilateral, the male organ was without bristles, and the remainder of the sexual organs were only imperfectly developed. He also, in an *Anas marila* that was shot on the east coast of Jutland, found besides *Taenia tenuirostris* numerous tape-worms which he felt he must refer to as being *T. microsoma.* They were about 30 mm. long. In some instances the strobila contained 500 segments in a very loose condition, and the last segments contained mature eggs. The hooks on the rostellum (Krabbe gives no number) were 0·036 mm. Krabbe's *Bidrag til kundskab om Fuglenes Baendelorme*, p. 48, No. 53, figs. 146–56.

Description of Strobila.

The maximum length of my specimen was 3·712 mm., and the breadth of the terminal segments 0·245 mm. The greatest number of segments in a strobila was twenty-five. The scolex is sub-globular, but liable to variation, and bears four large suckers (Fig. 3). The rostellum when everted is long, 0·203 mm., similar to that of *longirostris*, and at its proximal end is a bulb 0·044 mm. in diameter, which bears a crown of *ten* sickle-shaped (*Drepanidotaenia*, Railliet) hooks 0·034–0·035 mm. in length. Length of scolex approximately 0·135 mm., diameter 0·203 mm. Neck short, 0·07 mm. in length. Segments sharply defined at base of neck. The following table gives the length and breadth of the various segments in the strobila :

STROBILA.

SEGMENTS.

Nos.	Length.	Nos.	Breadth.
1	0·043 mm.	Neck	0·101 mm.
2	0·05 ,,	1 16	0·101 ,,
3 5	0·067 ,,	17 19	0·135 ,,
6 9	0·084 ,,	20	0·17 ,,
10 12	0·111 ,,	21 23	0·203 ,,
13 16	0·118 ,,	24 25	0·245 ,,
17 19	0·135 ,,		
20 22	0·169 ,,		
23	0·203 ,,		
24	0·34 ,,		
25	0·371 ,,		

Chalk Corpuscles.—Excepting in the vicinity of the base of the suckers, and here they are very sparingly distributed, there are none in the strobila.

The nervous system could not with any definite certainty be traced.

Muscular System.—There are apparently sixteen longitudinal muscles, eight ventral, and the same number dorsal. They are arranged equidistant, and are composed of a number of smaller muscle fibres which in the genital segments dissociate themselves. These bundles are 3μ in diameter. There is also a series of smaller muscles running longitudinally through the parenchyma of the strobila, offshoots from which spread themselves transversely, proximally and distally over the tissue, and thus form a plexus in the segment. This is shown in the ends of detached or teased-out segments. When the rostellum is everted and the hooks sunk in the scolex, there is still a portion of the rostellum extruded, and from the crateriform inversion can be traced four protractor muscles running downwards, and attaching themselves to the proximal circular periphery of the bulb. The bulb is composed of a series of dense muscular ridges, in the grooves of which are seated and attached the ten sickle-shaped hooks. When fully extruded, as in Fig. 3*a*, four retractor muscles—possibly but a continuation of the protractors, as they are attached at the same point on the periphery of the bulb—run longitudinally to the pyriform base, where they bifurcate and attach themselves to the sides of the concavity. These retractors are attached individually to circular muscle bands, Fig. 3*b*, running the whole length of the attenuated rostellum, as in the rostellum of *H. gracilis*; their commissures are somewhat swollen. From the exterior or convex portion of the pyriform body of the rostellum is given off in a radiate manner numerous minute muscle fibres which imbed themselves in the surrounding tissue of the scolex.

Excretory System.—The ventral and dorsal canals lie longitudinally nearly in the same plane and are 0·027 mm. from either lateral border, and their transverse canals are on the extreme posterior margin of the segment. The former has a diameter of 14μ, and the latter 6μ.

Description of Genital Segments.

No sign of the formation of the genitalia can be traced until the fifteenth segment from the neck in each of my specimens; this was a fixed number. Then, in this segment there appears a triple aggregation of detached cells, somewhat pigmented, which in the following segments are evolved into the three orbicular testes. The cirrus with its pouch and bursa copulatrix is in this segment imperfectly developed, and in the anterior distal dorsal corner is to be seen the wrinkled outline of a cuticular sac which in the succeeding segment becomes the vesicula seminalis exterior. In this segment the male organ of copulation with the female vagina—in the same sinus—and vaginal canal are perfected; the testes, having completed their functions by filling the vesicula seminalis exterior, are in the initial stage of absorption, and that organ has passed the sperm on to the vesicula seminalis interior within the bursa. The receptaculum is hanging diagonally—empty—at the end of the vaginal canal, and thus this proglottis may be looked upon as the perfected hermaphrodite segment, because in the next segment coition has taken place. The vesicula seminalis exterior is a shrivelled, empty sac, the testes have disappeared dorsally, the duplex semilunar ovaries have taken their place ventrally-transversely in the segment, the globular yolk-gland lying between them dorso-ventrally, and in close proximity is the shell-gland. In the ante-penultimate segment, with the exception of the receptaculum seminis, the organs of generation, if not totally obliterated, are but faintly visible, and what was originally the ovaries—for nothing of a *uterine canal* can be traced—has now resolved itself into a somewhat *v*-shaped uterus, with the ductus efferens of the receptaculum seminis attached to the utero-ovarian membrane. In the penultimate segment the receptaculum has disappeared, the ovaries have become a closed *v*-shaped uterus. Here the impregnated ova are not *ripe*, but in the ultimate or terminal segment have become so—*i.e.* the embryo is a perfect hexacanth or six-hooked brood, ready for transmission to its intermediate host. These transitions are shown in the seven segments, Fig. 5, and are an enlargement of Fig. 1, which is a perfect worm—that is, it has not shed any of its segments.

Description of Genitalia.

The genital pores are unilateral on the proximal lateral border, both male and female being in the same sinus. The male pore is anterior to the female. The male genital pore is circular, and has a diameter of 0·013. mm. The bursa copulatrix lies diagonally in the segment, and occupies about two-thirds of the angle of the segment, and is 0·017 mm. in cross section. It contains the vesicula seminalis interior, and the cirrus, with its pouch and sheath. The cirrus is hispid; when exerted it is 0·024 mm. in length, 0·007 mm. in breadth, and is *not* claviform. The sheath is a prolongation of the cuticle of the vesicula seminalis interior. It is 0·02 mm. in length. From the distal end of the cirrus and through the sheath runs a convoluted duct, which expands into a heart-shaped expulsion bladder, and from this succeeds the vesicula seminalis interior, which is a long narrow sac occupying the middle portion of the bursa, and is filled with sperm. At the end of the sac is a protrusible fundus with a circular orifice and a sinuous duct. The wall of the bursa coalesces with this duct, and is prolonged into the ductus efferens of the vesicula seminalis exterior, which is an orbicular sac with a diameter of 0·074 mm.; the sperm-mass occupies the central portion of the clear space. The three semi-orbicular testes have each a diameter of 0·034 mm.; their efferent ducts, which are offshoots of the membranous sac, coalesce with the vas deferens, which is an arched duct from the proximal to the distal testes, and it then runs vertically to the vesicula seminalis exterior (Fig. 8).

The female genital pore is very obscure. It is a simple oval aperture; the vagina is campanulate and the vaginal canal filiform. It terminates in the receptaculum seminis, which in the mature hermaphroditic segment lies diagonally, but in the succeeding segment is then nearly vertical and pyriform. Its vertical axis is 0·07 mm. and its equatorial 0·04 mm. The yolk-gland is orbicular; it is situated between the ovaries in the posterior middle portion of the segment; it is composed of a series of lobules, from whose converging ducts issues a common duct, the ductus efferens. The shell-gland is composed of three acini, a comparatively large central one and two small, one on either side; their common duct, like the efferent duct of the yolk-gland, forms a junction with the efferent duct of the receptaculum seminis. It is situated ventrally, and is difficult to localise, being partially covered dorsally by the yolk-gland and ventrally by the posterior portion of the ovaries. The ovaries in their initial stage are crescentic, the side in proximity to the yolk-gland being concave. They are continuous by the joining of the thin posterior horn of the ovisac; they are thus semi-duplex. The proximal ovary has a diameter of 0·034 mm. and the distal 0·027 mm. No trace of a uterine canal is visible, and in the succeeding segment the receptaculum filled with semen is seen to be attached by its efferent or sperm duct to the ovisac or cuticle of what were the crescentic ovaries, but have now become the unequal *v*-shaped uterus, as its impregnated ova indicate, which also becomes equally developed in the two terminal segments. If such be the case, that the ovaries fulfil the dual capacity of ovary and uterus, then the yolk- and shell-gland must pour their secretion together with the spermatozoa from what in other cestodes is the ductus efferens of the receptaculum seminis, directly into the ovaries, and that there the ova become fertilised, and develop into the hexacanth or six-hooked brood. This is not a postulate or conjectural theory, because the impregnation and the development of the ova into the six-hooked brood within the original ovisac give credence to such a view, there is no oviduct or emissary pore from either ovary, (Fig. 8, ♀), although admittedly I have not been able to trace the presence of the emitted spermatozoa within the sac or in the act of impregnation.*

In the penultimate and ultimate segments the ripe ova or six-hooked brood are contained in a *v*-shaped uterine sac. They are elliptical, and have an equatorial diameter of 0·034 mm. and polar axis 0·044 mm., and but two enveloping membranes could be traced. The diameter of the embryo is 0·02 and length of embryonic hooks 0·013 mm.

Like Pagenstecher and Krabbe, I found isolated specimens of egg-masses (Fig. 7) amongst the faeces of the same wild duck

---

* The regrettable thing in connection with this is that in my endeavour to discern the sperm by the aid of an immersion lens I accidentally crushed my specimen which I had under observation for that purpose, and being mounted in glycerine it readily yielded to the slight pressure from the fine adjustment.

DESCRIPTIVE

Nos. 1, 2, 3, 4, *Taenia microsoma* Creplin

	SCOLEX.	ROSTELLUM.	HOOKS.
No. 1. CREPLIN . .	Variable in form, suckers large, neck short.	Elongate, claviform.	*Inerme.*
No. 2. PAGENSTECHER .	No description.	No description.	10, small hooks no length given.
No. 3. PFAFF AND OLRIK	No description.	Long slender spindle; knob formed.	10; 0·037–0·061 mm. in length.
No. 4. KRABBE . .	No description.	No description.	10; 0·043 mm. in length.
No. 5. ROSSETER . .	Sub-globular, but variable in form, four orbicular suckers, neck short.	Elongate, filiform; bulbous or knobbed.	10; 0·035 mm. in length. *Drepanidotaenia.*

TABLE OF

and No. 5, *Hymenolepis upsilon.*

STROBILA. Length and Breadth.	NUMBER OF SEGMENTS AND DESCRIPTION.	GENITALIA. Male and Female.	EMBRYONIC EGGS.
7–13 mm. —	Very short; no number given.	♂ Cirrus cylindrical, claviform. ♀ No description.	No description.
No length or description given.	Never more than 21.	Genital organs symmetrically placed in strobila.	Terminal segments contain unripe ova, but egg-masses found developed amongst faeces.
12 mm. × 0·5 mm. 40 mm. —	150–180 segments. 500 segments. Very much broader than long, tongue-shaped.	Genital pores unilateral. ♂ 0·084 mm. long, covered with bristles or thorns. ♀ No description.	12 mm., only immature eggs. 40 mm., terminal segments, ripe eggs in masses.
2 mm. × 0·3 mm. 30 mm. —	60 segments in strobila. 500 segments in strobila.	Genital pores unilateral. ♂ Cirrus without bristles, other organs very imperfectly developed; 500-segmented worm hermaphroditic segments perfected.	In 30-mm. worm the terminal segments contained ripe ova.
3·712 mm. × 0·245 mm.	Maximum number of segments in strobila twenty-five; terminal seven segments, sexual and mature.	Genital pores unilateral. ♂ Cirrus hirsute. Three testes, vesicula seminalis exterior and interior. ♀ Vagina in male sinus, receptaculum pyriform, shell- and yolk-gland; ovaries crescentic, fulfil functions of uterus, which is in the form of a Greek *v*.	Six-hooked brood in terminal segments. Embryonic hooks 0·013 mm. long. Embryo contained in two envelopes, possibly three. Egg-masses found amongst faeces, the eggs with three distinct envelopes.

that my specimens were taken from, and like them I drew the inference that they were analogous. I shall again refer to these egg-masses.

The foregoing table with an epitome of Krabbe's monograph of *T. microsoma* and a summary of my specimen will enable the reader and student in this branch of helminthology to compare the details of that avian tape-worm with this that is under consideration. As the description given by Krabbe and even by Dujardin of the Schilling-Creplin worm is comparatively of little value beyond the specific character *microsoma*, a small-bodied tape-worm, the difficulty is rendered greater by its being stated to be *inerme.*

In those specimens which Pfaff and Olrik found, and which Krabbe examined, their lengths up to a certain point agree with Creplin's worm, but in Pagenstecher's specimen the length is excessive in comparison. The number of hooks in either instance agrees; but no length or delineation being given by Krabbe of the hooks in Pagenstecher's specimen, one cannot make any comparison between them.

Those specimens which Krabbe took from *Anas fusca* and *marila*, in the former, like Pagenstecher's, they were 2 mm. long and the genital apertures were unilateral; but, excepting the male organ, unlike Pagenstecher's the other genital organs were but imperfectly developed. Numerically the hooks were the same as the above, but a few millimetres larger than the smallest in the Pfaff-Olrik collection. In *marila* the length of the strobila has increased to 30 mm. with 300 segments, and their terminal segments contain mature eggs; whilst the hooks of the rostellum (no number is given by Krabbe) are normal with the smallest in the Pfaff collection. Such being the case, I have to consider the specific relationship of my specimen with the above helminthologists' *T. microsoma.*

Excepting the hooks, Creplin's specimen being hookless, the length of the strobila and number of segments of Pfaff and Olrik's and Krabbe's larger specimen, as described above, precludes, in consequence of their disparity, any comparison with my specimen. Thus we are left with Pagenstecher's specimen with *twenty-one* segments, the terminal ones containing unripe ova—consequently the preceding segments were hermaphroditically perfect; and Krabbe's 2-mm. specimens with *sixty* segments, in which the genitalia were but rudimentary. Thus, although Krabbe gives no length, Pagenstecher's worm, I compute, could not have been more than 2 mm. in length; and Krabbe's 2-mm. worm was, I am led to deduce from the rudimentary condition of the genitalia, but a young specimen of his larger or 30-mm. worm with 500 segments.

In comparison with my worm, whose greatest length is 3·712 mm., and breadth 0·245 mm., consisting of twenty-five segments, the strobila and the segments are greatly out of proportion in length and breadth compared with Krabbe's 2-mm. specimen. In the case of Pagenstecher's specimen I am inclined to the opinion that his worm is identical with mine; for if *four* segments were added to a worm which contained unripe ova, and assuming that each of these segments was, as in the twenty-fifth segment of my worm, 0·371 mm. long, Pagenstecher's worm would then read thus: 21 segments = 2 mm. + 4 segments × 0·371 mm. = 1·484 mm. + 2 mm. = 3·484 mm., the equation of my specimen, less 0·228 mm. They would thus have been elongated to 3·484 mm., and would undoubtedly have developed into mature or ripe segments in the strobila with the peculiarly formed egg-masses which he found amongst the faecal substance in the duck. Considering that Creplin's worm *microsoma* is supposed to have been *inerme*, the omission by Krabbe in his drawings of the cephalic hooks of Pagenstecher's specimen, in comparison with his own, is regrettable; they would have been invaluable, for then we should have had a surer and broader basis for the determination of this species, as the term *microsoma*, as I have said above, is vague, and might with propriety be applied to other species of avian tape-worms. Krabbe does not appear to have convinced himself from an inspection and comparison of the hooks of his 2-mm. worm with the hooks of Pagenstecher's specimen that these two worms were identical. To compare this species of avian tape-worm, *microsoma*, with its narrow attenuated segments, with that of mine, the breadth of whose terminal segment is two-thirds its length may well seem anomalous, the gradation of the last seven segments in the evolution of the genitalia being definitively marked, and only *one* segment in the strobila a perfect hermaphrodite segment. Then again, although the cephalic hooks in my specimen, Fig. 4*e*, are a trifle shorter than Krabbe's 2-mm. specimen, Fig. 4*d*, yet otherwise they are a facsimile of *c*, Fig. 4, in Pfaff and Olrik's collection, with which Krabbe was conversant; although, like Krabbe, I look upon it as a somewhat doubtful proceeding to judge a species by the hooks alone, yet if the hooks of Pagenstecher's specimen are identical with *c* and *d*, Fig. 4, then I am prepared to admit that my specimen and Pagenstecher's are one and the same species.

According to Fuhrmann, Cohn studied this worm *microsoma* and classified it as *Dilepis microsoma*, but afterwards reclassified it as *Hymenolepis microsoma*. In the first instance Cohn was in error, as both sexual pores are in the same sinus. I am not acquainted with Cohn's work on this species, but I agree that its generic name is *Hymenolepis*, in contradistinction to *Taenia*.

Although Krabbe says that the egg-mass squeezed out of the last segments of the 40-mm. worm in Pfaff and Olrik's collection was similar to Pagenstecher's, yet we get no information otherwise from Krabbe of these "*snore-Aeggemasse.*" On comparing the detached proglottides I found amongst the faeces of the duck, and containing the *v*-shaped uterus, with the ultimate or twenty-fifth segment of my specimens, I found they had elongated themselves 0·439 mm. and expanded 0·025 mm. in excess. The fact that the intestinal tract of the duck contained no other species of tape-worm was convincing proof to me that these separated proglottides were detached portions of the strobila of this worm, and consequently I must give credence for Pagenstecher's being the same. The aggregation or massing of the uterine eggs also occurs, according to Krabbe, in *T. circumcincta* (Krabbe, No. 21). In the gravid segments of *Liga brasiliensis* (*vide* Ransom's *Taenoid Cestodes of North American Birds*, p. 24, fig. 13) the uterine mass is similar to the *v*-shaped uterus in my specimen.* But then too much stress must not be

---

* Since the above was written I have found amongst the faeces of the lower intestine of a mallard duck a globular sac containing tape-worm embryos in the hexacanth stage of development. It was 0·643 mm. in diameter; it contained from 200 to 250 embryos 0·03 mm. in diameter and embryonic hooks 0·013 mm. in length. The embryos were enclosed in other globular sacs whose contents varied from three to eight in a group. On comparing with the uterine proglottides of *Aploparaksis* (*Taenia*) *furcifera* (*rhomboidea*), and seeing that this portion of the duck's intestine was infested with this species, I am inclined to think that this is a uterine sac, the product of and expelled from a disintegrated terminal segment of the same (Fig. 9).

laid on the egg-mass either generically or specifically, because, although in the case of *Liga* the length (3 mm.) and number of segments (16) bring it into line with mine and Pagenstecher's specimens, yet in other essentials the generic characteristics are totally different, and this difference excludes it from the genus *Hymenolepis*; and these remarks also apply to *Anomotaenia* (*Taenia*) *constricta.*

The question of the greater proportional length, and consequently the increase in the number of segments, raises a doubt in my mind as to the claim for Pagenstecher's specimen of being specifically the same as Creplin's *microsoma.* This disparity in the length of the strobila, the number, length and breadth of the segments composing it, of those specimens of *microsoma* in the Pfaff-Olrik collection and those Krabbe found; also their sexual development apart from the egg-masses in the 500-segmented worms, is convincing proof to me that, although the cephalic hooks as figured by Krabbe, more especially Fig. 4*c*, are in agreement with mine, Fig. 4*e*, they are specifically distinct. The doubt of Pagenstecher as to his worm being Creplin's *microsoma* in the absence of the hooks in the latter is quite admissible, and I am convinced that, although the strobila of his worm was shorter and contained fewer segments than mine, the developed hermaphrodite condition of the genitalia in the strobila, also the form of the egg-masses both in the last segments and in separated free proglottides in the intestine, point to them as being identical. On this divergence in the form of the strobila, and on a comparison of the development of the sexual organs in the same and subsequent uterine mass, I base the conclusion that neither my specimen nor that of Pagenstecher's is identical with Creplin's, Pfaff and Olrik's, or those specimens known by Krabbe himself as *Taenia microsoma.* Generically, *Hymenolepis*, both my specimen and that of Pagenstecher, will remain the same; but the specific name, *microsoma*, of Pagenstecher will be deleted, and, together with mine, will, from the similarity of the character of the uterine sac to the Greek small υ, receive the specific name of *upsilon.*

The dualism of the ovarian uterine sac to which I have above called attention is, as far as I know, a unique character, it being possessed by no other avian tape-worm; yet I think that it is not of sufficient importance for the formmation of a new genus, as the hermaphroditic arrangement of the generative organs are known to present great variations: neither do I look upon it as an abnormality, but I rather favour the possibility of its being a reversion in this instance to an original form.

Description of Plate 6.

Fig. 1. The entire worm, × 35.

,, 2. The scolex with rostellum retracted × 70.

,, 3*a*. The scolex under pressure, to show suckers; also rostellum with bulb, minus the hooks × 70.

,, 3*b*. Longitudinal and circular muscles of the rostellum, diagrammatic.

,, 4. Hooks from the rostellum. *a*-*c*, Pfaff and Olrik's specimens; *d*, Krabbe's specimen × 920 (after Krabbe); *e*, from *Hymenolepis upsilon* × 700.

,, 5. The last seven segments in the strobila to show evolution of the genitalia. For references see Fig. 8.

,, 6*a*. Embryonic egg from terminal segment.

,, 6*b*. From uterine sac of free proglottis × 350.

,, 7. *v*-shaped uterine sac from free segment × 35.

,, 8. Isolated male and female organs, diagrammatic. ♂: *c*, cirrus; *c s*, cirrus sheath; *h v*, heart-shaped vesicle, possibly expulsion vesicle; *c p*, cirrus pouch; *v s i*, vesicula seminalis interior; *v d*, vas deferens; *v s ex*, vesicular seminalis exterior; *v e*, vas efferens; *t t t*, the three testes.

♀: *v p*, vaginal pore; *v*, vagina; *v c*, vaginal canal; *r s*, receptaculum seminis; *o o*, ovaries; *s g*, shell-gland; *y g*, yolk-gland.

,, 9. See note p. 158.

ON THREE NEW SPECIES OF ROTIFERA.

By Charles F. Rousselet, F.R.M.S.

(*Read January 24th*, 1911.)

Plate 7.

From time to time collections of Rotifera from various parts of the world are sent to me for examination, and occasionally these contain very interesting new forms which have not previously been recorded. The three species here described were obtained in this way.

1. **Anuraeopsis navicula** sp. nov. (Pl. 7, Fig. 1).

In 1904–5 Prof. A. Borgert visited Ceylon and brought back samples of plankton collected in Lake Gregory, situated in the Central Province of Ceylon, at an altitude of about 6,000 feet.

This plankton material, as well as the physical conditions of this lake, have already been reported upon by Prof. C. Apstein, of Kiel,* who has been good enough to send me a small sample of the tow-netting in order to determine this small Rotifer, which I found to be undoubtedly new, and to which I have given the above name.

The generic name of Anuraeopsis was proposed by Prof. R. Lauterborn in 1900 to receive Gosse's well-known species *A. hypelasma*, which is altogether different from all the other species of Anuraea by being devoid of all spines and by other characters.

The present new species also has no spines, and appears to belong to this genus, although the details of its anatomy are as yet unknown. Like *A. hypelasma*, it is very small in size, and has a very thin and delicate lorica of light-brown colour.

---

* C. Apstein, "Das Plancton des Gregory-Sees auf Ceylon," *Zool. Jahrb.*, 1910, Bd. 29, pp. 661–80.

In general appearance the lorica is boat-shaped, with a sub-rectangular opening in front and a smaller opening posteriorly. The frontal edge is bilobed, the mental edge straight, and the whole anterior edge is finely serrated. The dorsal plate is arched, whilst the ventral plate is flat and smaller, and overlapped by the dorsal plate. A side view enabled me to see that the ventral plate is quite separated from the dorsal plate, or probably connected with it by a flexible membrane. The entire lorica is finely stippled all over.

The living *Anuraeopsis navicula* has not been observed, as only preserved material was available. The size of the lorica is 92 μ ($\frac{1}{276}$ in.) only; thus it is one of the smallest species of Rotifera.

I am indebted to Mr. A. Hammond for the accompanying figures, which give a very good idea of this animal's appearance.

2. **Brachionus satanicus** sp. nov. (Pl. 7, Fig. 2).

The difficulty of finding new and suitable names for new species of Rotifera is becoming more and more acute, so the above may be excusable and not inappropriate for a Brachionus which inhabits the Devil's Lake in North Dakota, U.S.A. I have little doubt, however, that it is a very gentle and inoffensive creature, like all the members of this genus.

The shape of *B. satanicus*, as shown in Fig, 2*a*, is very remarkable, and unlike anything known. I found this new species in some plankton material collected in the above-named lake and sent to me by Prof. R. T. Young, of North Dakota University.

The lorica is much compressed and nearly flat, sub-quadrate in shape, narrowest in front, widening posteriorly, where it is prolonged into two stout and long, symmetrically curved spines, equalling the lorica in length. Anteriorly the dorsal edge has six very small, nearly straight spines, the middle pair being slightly larger than the others, with a rectangular sulcus between them. The mental edge has four distinct spines, the shape of which is best shown in the figure (Fig. 2*b*). The foot-opening is simply a wide transverse slit between the dorsal and ventral plates, without projection of any kind.

It may be necessary for me to say that this new species has no affinity to *B. Bakeri*, or any of its numerous varieties. The chief characteristic of the latter, as I have stated in a previous communication, is a tubular prolongation of the lorica round the foot-opening, forming a distinct chitinous sheath through which the foot passes. Nothing of this kind is present in *B. satanicus*, which really forms a new type in this genus.

The foot is long, stout and wrinkled, ending in two small toes. The lorica is of glassy transparency, though there is a faint indication of stippling on the posterior spines.

An eye has not been observed in the preserved specimen, but is no doubt present, and its jaws and general anatomy appear not to differ from other members of the genus, though the corona may possibly vary on account of its small size.

The total size of *B. satanicus* is 380μ ($\frac{1}{67}$ in.), half of which is due to the large posterior spines.

Mr. F. R. Dixon-Nuttall has been good enough to draw Fig. 2 for me.

3. **Brachionus havanaensis** sp. nov. (Pl. 7, Fig. 3).

Some fourteen years ago Mr. A. Hempel sent me some plankton material collected by him in the Illinois River, near Havana, U.S.A. In this material I found, amongst other species, two empty lorica of this small and strange Brachionus-like Rotifer. Mr. F. R. Dixon-Nuttall made the sketch Fig. 3 at the time, which I have kept by me in the hope of being able to ascertain more about it, but so far it has not occurred again anywhere.

The lorica is firm and smooth, high in the back, and of usual Brachionus type, though differing from any known species in the frontal and posterior appendages. The anterior dorsal edge has six sharply pointed spines, the outer pair being slightly larger than the middle pair, whilst the intermediate pair are very short. The mental edge, as shown in Fig. 3*c*, has two projections corresponding to two strong ridges running backwards.

Posteriorly the lorica terminates in two long spines, close together, guarding the foot-opening, which are unequal in size, the spine on the right side being the longest.

Of the animal itself nothing at all is known, and it is hoped that the publication of these figures will assist in its being again discovered.

The total size of the lorica, including anterior and posterior spines, is 282μ ($\frac{1}{90}$ in.)

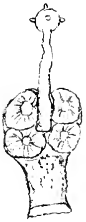
Description of Plate 7.

Fig.	1*a*.	*Anuraeopsis navicula*,	dorsal view, × 650.
,,	1*b*.	,, ,,	ventral view, × 650.
,,	2*a*.	*Brachionus satanicus*,	dorsal view, × 200.
,,	2*b*.	,, ,,	anterior mental edge, × 200.
,,	3*a*.	*Brachionus havanaensis*,	dorsal view, × 300.
,,	3*b*.	,, ,,	side view, × 300.
,,	3*c*.	,, ,,	anterior mental edge of lorica, × 300.

Journ. Quekett Microscopical Club, Ser. 2, Vol. XI., No. 68, April 1911.

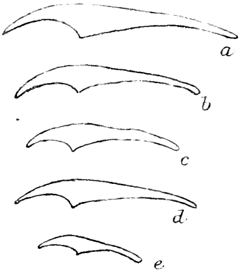
1.

2.

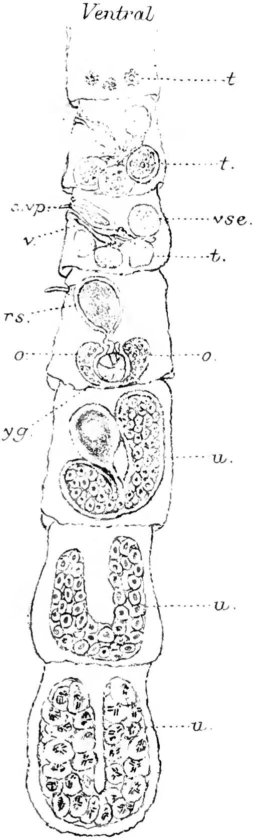


3.a

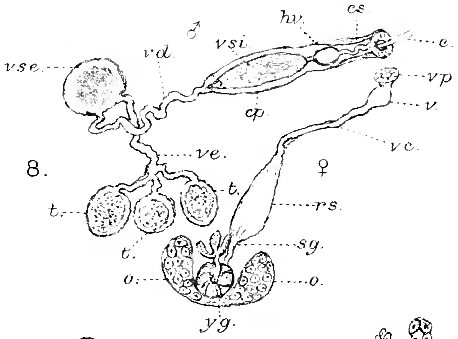
3.b



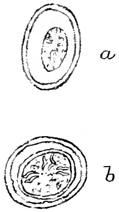
4.



5.

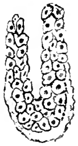


8.



6.

9.

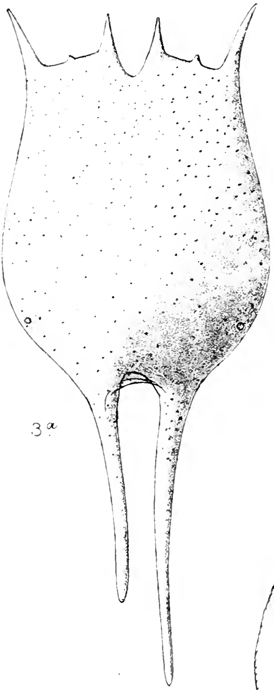


7.

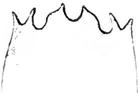
T. B. Rosseter, del.

A. H. Searle lith.

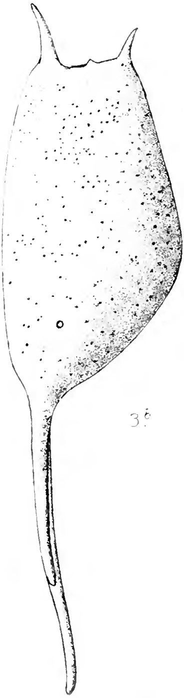
Hymenolepis upsilon *sp. nov.*



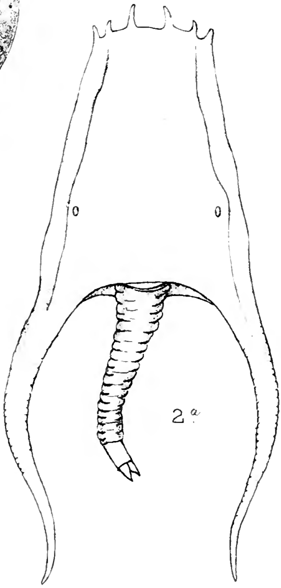
3a.



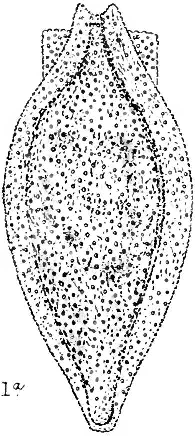
2b.



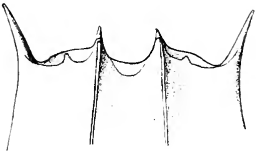
3b.



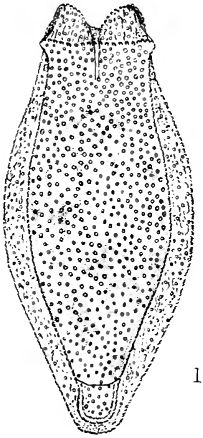
2a.



1a.



3c.



1b.

F. R. Dixon-Nuttall and A. Hammond. del. ad nat. A. H. Searle lith.

New Rotifers.

THE PRESIDENT'S ADDRESS.

SOME PROBLEMS OF EVOLUTION IN THE SIMPLEST FORMS OF LIFE.

By Prof. E. A. Minchin, M.A., V.-P.Z.S., F.L.S.

(*Delivered February* 28*th*, 1911.)

Gentlemen,—

When we survey with comprehensive outlook the world of animated beings around us, our senses, or rather the limitations of our senses, suggest to us at once a subdivision of living things into two categories, which are natural and obvious from a human standpoint, though not necessarily scientific on that account. In the first place, there is the every-day visible world of animals and plants, familiar to us since we first opened our eyes on this planet, in all its variety of character and luxuriance of form. In the second place, there is the invisible world of minute life which the microscope reveals to us, no less varied or exuberant than that of which we are made aware by our unassisted vision.

Taking first that visible world of living creatures with which every human being is acquainted, no deep reflection or analysis is required to grasp the fact that it does not constitute a chaos of isolated and unconnected forms, but is capable of being classified into greater or lesser categories. Popular speech shows us that the most uninstructed person is aware of this, though it may be unconsciously. The first and most obvious division of visible living things is into animals and plants. So far scientific and popular opinion are in accord, and the same is true, more or less, with regard to the smallest groups of forms that receive a common name, namely, kinds or species. Such words as cat, horse, dog, elm, oak, correspond fairly closely with species or groups of species recognised by the scientific man.

But between the categories of greatest and least extent, there are a number of intervening subdivisions, with regard to which the scientific and the non-scientific public are hopelessly at variance. The same is inevitably true in any branch of knowledge dealing with concrete objects, simply because the mind devoted to the study of any particular set of things, animate or inanimate, soon becomes perforce acquainted with a variety of objects so far exceeding that which ever comes within the ken of the casual observer, that in order to arrange them in an orderly and intelligible system of classification, it is necessary to draw distinctions and institute comparisons which are never dreamt of in the philosophy of the mind occupied with other pursuits.

Hence there is a great contrast between scientific and popular systems of classification, especially when dealing with living things. The classification used by the expert is bewildering and unintelligible to the popular mind, while to the serious student, popular classifications are often naïve, inadequate and ludicrous in the extreme. Take for instance the animal kingdom; popular speech recognises five classes as follows: (1) "animals," a word which now generally replaces the Biblical term "beasts," and which is sometimes qualified further as the "lower animals," to distinguish them from the self-styled lord of creation, the higher animal, man; (2) "birds"; (3) "reptiles"; (4) "fishes"; and (5) "insects." The last comprehensive division includes practically all that the zoologist terms invertebrates, except a few popularly classed as reptiles or fishes. Even the forms of life known to the zoologist as Protozoa would be termed "insects" without hesitation by the uninstructed. This primitive five-fold classification of animals is by no means peculiar to the illiterate or the uneducated; it is met with in the writings even of men learned in other branches of knowledge. In one of the Fabian Essays the worker in a modern community is compared to a coral-insect in a sponge, by a writer evidently quite unaware that the coral-producing organism is not an insect, and that in any case it would not be found in a sponge.

The almost painful divergence between scientific and popular notions with regard to natural objects is not, however, a chasm which was split open, so to speak, by a single shock. Scientific classifications did not spring in one instant from the scientific brain, like Pallas Athene in full armour from the head of Zeus, previously vexed by a slight headache. On the contrary, modern classifications of living beings are the outcome of a long, slow, and often painful process of growth and evolution in the past, and are undergoing daily further modifications in the incessant striving towards the goal of unattainable perfection. The first scientific zoologists used classifications scarcely more elaborate than those in popular use. Each worker climbs by the help of those who have gone before, and adds laboriously his pebble to the pile they have raised.

The invisible or microscopic world stands on a very different footing in relation to human knowledge. Its cognisance does not come within the scope of the unassisted human senses, consequently the vast majority of mankind pass through life without the reality of this world of minute creatures ever being brought home to them, at least as an actual and concrete fact. They may read or hear of the existence of living beings which are vaguely referred to as "microbes," or by the misapplied word "germs," but these mystic creatures remain words, mere words, as unreal

> As the gay motes that people the sunbeams,
> Or likest hovering dreams
> The fickle pensioners of Morpheus' train.

No detailed descriptions or figures can possibly convey by themselves any tangible idea of microscopic objects. The microscopist's unit of measurement, a micron, impresses the mind with no more sense of actuality than the astronomer's unit of a million miles.

It is the microscope, the instrument for the cultivation and application of which this Club exists, that has brought this vast medley of living things within the range of human perceptions. The microscope has discovered a new world for us, and its help is indispensable in exploring and administering the newly acquired territory. But the microscope, as compared with the human race, even as compared with civilised man, is relatively a thing of yesterday. Great minds have lived and died, vast systems of philosophy have been founded, before anything that we should call a microscope came into existence, before anything was known of the great invisible world of lower organisms, for which I shall use Haeckel's convenient term the Protista.* And the microscope is itself an instrument which is growing, evolving, daily becoming more efficient. It is not yet adequate for our needs, for we know on the surest evidence that there are living

---

* For the purposes of this address, I leave out of consideration those microscopic organisms, such as Rotifers, which belong to a higher rank.

things which it cannot show us, forms of life the nature of which we can only vaguely conjecture.

Small wonder, then, if our knowledge of the invisible world of organisms be still in a primitive state, especially as regards the general lines upon which the simplest forms of life should be classified. It is not too much to say that the classification of the Protista has scarcely advanced, even amongst experts, beyond a stage comparable to the popular classification of animals set forth above. A certain number of groups are recognised, and everything is expected to fit into one or another of them. If I express my honest opinion that a spirochaete should not be classified amongst the Protozoa, I am usually asked at once if I think it should be placed in the group Bacteria; just as the statement made to an unscientific person that an earth-worm is not an insect generally leads to the question whether it is a reptile.

In the great forests of the tropical zone there are many species of animals of various classes belonging to what may be called the tree-top fauna. Such are, for instance, the marmosets in South America. We may imagine that a marmoset, born and brought up amongst the topmost branches of lofty trees, might be ignorant for some time that the trees have stems, and might never, in all its life, become aware that they have roots also. Some chance hazard, such as the uprooting of a tree by a storm or an earthquake, might reveal to it one day the remarkable fact that the trees on which it had lived all its life have roots, and if it were capable of reflecting on such a matter, it might note with astonishment that the hidden roots were as extensive in their ramifications as the branches exposed to the light of day.

We human beings belong, so to speak, to the tree-top fauna of the organic world. Living amongst the highest branches of the great tree of life, of which we like to believe ourselves to be the topmost twig, the roots of the tree are buried and concealed from us, until the microscope reveals them to our astonished gaze. Then we slowly become aware that the lowest forms of life which constitute the vast group of the Protista are in their range as extensive, in species as numerous, in character as varied, and in mode of life much more so, than the familiar living things of the visible world.

The human mind begins at once, almost instinctively, to group the objects brought within the range of its perceptions, expressing its classification by the help of language, and inventing new terms and names for things that cannot be designated fittingly by terms already in use; continuing, in fact, the work that Adam is said to have begun in the Garden of Eden. As time goes on, the progress of discovery necessitates the setting up of more and more of these new names and categories, and it is certain that in the case of the Protista the process is still very far from having been completed, and that much brain-energy is being wasted continually in trying to force new wines into old bottles, which must burst sooner or later. The case of the spirochaetes I have already mentioned; bacteriologists do not seem to want them, and recent researches on their development by Leishman and others indicate very clearly, in my opinion, that they have nothing to do with the Protozoa. Quite recently a new category has been founded, and given the name Chlamydozoa by Prowazek, to include the problematic organisms of small-pox, vaccine, scarlet fever, and a number of other diseases. I am frequently questioned as to the nature of these organisms by my bacteriological friends, who seem very often to think, that if an organism does not come under their department, it must come under mine. I can only say that, from a perusal of the latest writings on these Chlamydozoa, and from a scrutiny of the published illustrations of them, I am by no means prepared to admit them into the fold of which I am an appointed shepherd, if all that is stated about them be correct.

It must, I think, be obvious on reflection, that there is no reason whatever to suppose that the Protista can be partitioned out into the few subdivisions generally recognised. It is just as likely that a much larger number of groups must be admitted, and that the progress of microscopic investigations upon the minuter and less-known forms of life, some of them still invisible to us, will greatly increase the number of distinct categories that it will be necessary to set up.

In the present rather vague state of our knowledge concerning so many of the lower forms of life, it is scarcely possible to attempt to put forward any detailed scheme of classification of the Protista. The characters which determine the affinities and interrelationships of the known groups are difficult to state with any precision, and until we have a more thorough knowledge of the range of forms to be dealt with, it is premature to try to work out the lines of evolution and descent of the Protista as a whole, a study indispensable if the classification is to have any approach to finality. Nevertheless, I believe it is possible to lay down certain guiding principles which indicate the general trend and direction of evolution in the simplest forms of life, or at all events of that main stem which leads on towards the higher organisms; bearing always in mind that other branches may have taken other directions leading sideways or even downwards rather than upwards, just as in the Metazoa, one of the lowest branches, that, namely, represented by the Sponges, clearly does not lead on to any higher form of life.

But first I must say a few words about certain distinctions commonly drawn among living organisms. In the case of the visible world of living beings familiar to us in every-day life, the most obvious and natural division is into animals and plants. No distinction could be sharper or more incontestable. Consequently the human mind tends almost instinctively to place any living thing under one or other of these categories, and can scarcely be brought to conceive of any form of life as being possibly neither animal nor plant.

When we inquire on what the distinction of animal and vegetable is based, it is seen at once that it depends upon the manner in which the organism builds up its living substance, that is to say, upon those vital processes which the physiologist sums up under the term metabolism. All living bodies contain substances of great complexity termed proteids, the most complex chemical substances known to exist. A plant has the power of building up its proteids from simpler chemical substances; an animal has no such power, but must be supplied with food containing ready-made proteids, hence it cannot exist without plants or other animals to feed upon. In plants, however, the metabolism is by no means of one unvarying type, since green plants, by the aid of their green pigment, chlorophyll, or colouring matters of allied nature, can utilise the energy of the sun's rays in order to build up their proteids from the simplest inorganic salts and gases, while saprophytes, such as fungi, which have no chlorophyll, require for their nourishment organic substances—that is to say, substances produced by the vital activity or by the decay of other living organisms. Further, among both animals and plants we meet with the phenomena of parasitism, which need not be discussed at present; it is sufficient to point out that a parasite is an organism which invades or attacks some other organism in order to rob it of its proteids.

When the Protista are considered from the point of view of their metabolism, it is found that in one order, the Flagellata, all the four modes of metabolism just mentioned occur amongst organisms obviously most closely allied. Some have chlorophyll and live like green plants, others have no chlorophyll and live as saprophytes, others again like animals, or as parasites. But an even more remarkable fact is that one and the same organism can live at one time as a plant, at another as an animal. Some of the Chrysomonads have chlorophyll and live like green plants in the sunlight, but when the conditions are not favourable for this, they can capture and devour other organisms after the manner of animals. The common *Euglena* exhibits under ordinary circumstances the metabolism of a green plant, but when kept in the dark it is stated to be able to maintain its existence as a saprophyte. Nothing shows more clearly than these facts that the difference between plant and animal is, at its first appearance, only a distinction based upon a habit of life, a difference of degree and not of kind. If a Protist organism can be at one time a plant, at another an animal, according to circumstances, it is clearly impossible to use the distinction between plant and animal for the purpose of subdividing the Protista into two principal groups.

Whatever the primary and original form of life may have been—on this we can but put forward speculations—it must have evolved in many different directions, and developed various modes of vital activity. There is no reason whatever to suppose that the possible methods of metabolism in living beings is limited necessarily to two, three, or even a dozen or any other number. As a matter of fact we find among Bacteria types of metabolism which it is impossible to bring under the current limited classifications; organisms, for instance, which can fix free nitrogen, a thing unknown in any green plant, saprophyte, or animal, but quite as remarkable in itself as the fixation and decomposition of carbonic acid gas by green plants. Moreover, distinctions based upon metabolism and habit of life are quite unsuitable characters to use for purposes of definition and classification, at least at their first origin, since two closely allied organisms may adapt themselves to quite different modes of life. The distinction of animal and plant can only be used for classificatory purposes when, as in the higher organisms, it is so ingrained that the whole structure of the organism is modified in accordance with it.

The conclusion from these considerations is that it is no use to attempt to partition the Protista into two primary subdivisions, animals and plants. We must look for the more fundamental divergences along some other lines. But at this point I wish to enter a caveat, as the lawyers say, with regard to the logical aspects of the classification of living beings.

A classification, to be logically perfect, should divide the objects dealt with into groups of greater or less extent which are defined and distinguished from one another by precise characters verbally expressed. Such a procedure presents no great difficulties, as a rule, in dealing with inanimate objects, because their characters are stable and stationary. Take for instance any common chemical substance, such as carbonate of lime, or silica. There is no reason to suppose that the characters and properties of these substances have changed, or will change, in any finite period of time, however great. It is quite otherwise with living things; they have undergone, and are undergoing, continual processes of evolution and modification. If we could project our vision back to Silurian times, we should see scarcely a single living organism similar to those existing at present; and who can imagine dimly what will be the state of things in a future as far distant as the present is from the Silurian epoch? Possibly the earth may then be inhabited by one single species of organism, the final product of the evolution of man, who will by then have accomplished his apparent destiny of extirpating all other forms of life, and who will obtain the proteids necessary for his sustenance by the aid of chlorophyll manufactured artificially by the ton, and will supply all his wants by means of appropriate mechanical devices. Let us be thankful that we shall none of us live to see that day.

The continual process of change which living things undergo puts many obstacles in the way of strictly logical classification. In the first place, between any two forms of life, however far apart in the scale, intermediate forms must exist or must have existed.

In the second place, if a group be defined by certain characters, it is nearly always found that particular forms, though clearly shown by features of secondary importance to belong to the group in question, nevertheless lack entirely the characters we have chosen as diagnostic of the group. Living beings, adaptable in every direction, will always evolve themselves out of any definition that can be laid down. Thus it would be natural and reasonable to separate vertebrate animals into two main groups, one in which the paired limbs are of the type of fins, as in fishes, and one in which the paired limbs are pentadactyle in type, as in mammals, birds, reptiles and amphibia; but then we must include in our pentadactyle group the snakes and some other creatures that have no paired limbs at all, not to mention horses, in which the five digits originally present in each limb have become reduced to one in the course of evolution. Again in siliceous sponges, we can recognise a great natural group, the Tetraxonida, characterised by skeletal spicules with four rays, generally combined with star-like flesh-spicules, so-called asters; but in such a form as the common *Tethya** *lyncurium* the skeletal spicules are all reduced to simple needle-like forms; in the genus *Chondrilla* the skeletal spicules are gone altogether, and only the asters remain; and finally in the genus *Chondrosia* there are no spicules at all. The structural peculiarities, however, of *Tethya*, *Chondrilla* and *Chondrosia* are such as to leave no doubt whatever that they are closely allied to true Tetraxonida, and must be classified in this group; and thus we are brought to the apparently illogical result, that after having defined a group by certain characters, we are forced to place in that group forms which do not possess those characters.

A third limitation imposed upon us in the classification of living beings is that there are many possible systems of classification which may be flawless from the purely logical point of view, but which will not serve our purpose from the biological standpoint. We require what is termed a natural classification, that is to say, one which exhibits the true affinities and relationships by descent, so far as they can be ascertained, of the organisms dealt with. From the standpoint of strict logic there is nothing against subdividing animals by their habitat into terrestrial, aquatic and aerial; but then whales would be grouped with

---

* Now generally named *Donatia lyncurium* by nomenclature purists.

fishes, and bats with birds, and I need not waste your time by pointing out how unnatural such a method of grouping would be. Many perfectly logical classifications are possible, but only one that is perfectly natural, and that one, very often, is not perfectly logical in form.

The practice of classifying living things into systems more or less logical may be as old as Adam, but it arose in a time when living species were supposed to be as fixed and immutable as those of the inorganic world. *Tot sunt species quot ab initio creavit infinitum ens* was the dictum of Linnaeus, the father of modern classification of living things; but even in his time the existence of natural and artificial classifications was recognised, though the meaning of the difference was first made clear when the origin of species, through descent with modification from other forms, became an accepted notion. It is now abundantly clear that natural groups can seldom, if ever, be defined by precise and rigorous verbal definitions. All that can be done is to construct for each group a more or less ideal and imaginary type of organism, possessing certain characters, none of which must be regarded as fixed or invariable; what Delage and Hérouard call a morphological type in their great work, *La Zoologie Concrète.* If we must have verbal definitions of groups, then logic requires the insertion of the word "typically" before each character ascribed to them; thus Tetraxonida are Sponges which possess, typically, four-rayed siliceous spicules; Reptiles are, typically, pentadactyle Vertebrates. Only in one of these two ways can we effect a just compromise between the claims of strict logic and the exuberant versatility of Nature.

To return now, after this somewhat long digression, to the Protista. Can we recognise in them any prominent differences of character which may serve for the purpose of subdividing this vast group? As already stated, we abandon the time-honoured distinction of animal and vegetable as inadequate and impracticable in these lowly organisms. What can we use instead?

I believe myself that there are two well-marked types recognisable in the Protista, the one more primitive and older in evolution, the other higher and leading on to the ordinary plants and animals. As I have been at some pains to point out, the existence of two such types does not preclude—on the contrary it postulates—the existence in the present or past of every possible transition from the one to the other. The difference between these two types depends on the condition under which that peculiar substance occurs for which we may use, in quite a general sense, the term chromatin. In every cell of an animal or plant, and probably in every Protist organism, there is found a certain amount of substance remarkable for its affinity for certain colouring matters, and still more remarkable for the part it plays in all vital processes. From the first of these characteristics the name chromatin has been given to it. It is a substance, or combination of substances, of a very high degree of chemical complexity, perhaps more complex than any other substance, but it is by no means of uniform chemical composition; on the contrary, the chromatin in any given sample of living matter probably differs chemically, to a greater or less degree, from that found in any other sample. The term chromatin implies, in short, a biological or physiological, but not a chemical unity. It is a substance generally easy to recognise, but extremely difficult—perhaps impossible at present—to define.

In the lower type of Protist organisation, which is exemplified by the ordinary Bacteria, and which I shall therefore speak of shortly as the bacterial grade, the chromatin is present in the form of scattered granules, now generally termed "chromidia." In many cases the whole body in this type appears to consist of little, if anything, more than a single minute speck or thread of chromatin; in other cases several distinct grains can be made out, some of them possibly not true chromatin, but substances out of which chromatin is built up, or into which it breaks down, in the body.

In the second type of organisation, a certain amount of the chromatin may still be present in the scattered chromidial condition, but the greater part, and in most cases all, of the chromatin is aggregated into a compact mass termed the *nucleus*. Apart from the nucleus the remainder of the protoplasmic body is made up of a distinct zone or region called the *cytoplasm*, scarcely recognisable, if at all, in the bacterial type of organisation. The nucleus shows a wide range of structural differentiation and ever-increasing complexity of organisation. Consisting in the simplest cases of perhaps nothing more than a compact lump of chromatin, in its most elaborate type of structure the chromatin-grains are suspended at the nodal points of a delicate framework, which contains a fluid nuclear sap in its meshes, the whole enclosed in a distinct membrane. Other bodies, such as nucleoli, distinct in nature from chromatin, and kinetic mechanisms, so-called centrosomes or centrioles, may be present in addition. All these structural elements, framework, nuclear sap, membrane, nucleoli and centrioles, may be regarded as so many acquisitions in the course of evolution, ancillary to the original chromatin, the substance of primary importance in the life of the organism.

With differentiation of nucleus and cytoplasm the organism becomes what is commonly termed a cell; I shall therefore denote this type of structure briefly the cellular grade. A cell may be defined as a lump or corpuscle of protoplasm, differentiated into cytoplasm containing at least one nucleus. It is not correct, in my opinion, to speak of Bacteria as cells; they are Protista of a lower grade, in which the type of structure proper to a true cell has not been attained, in which concentration of the chromatin to form a nucleus has not taken place, and in which, consequently, no distinct cytoplasm has been differentiated.

The difference of structure between these two types or grades may seem at first merely one of trivial detail. There are some considerations which tend to show that it is far from being so, but that, on the contrary, the attainment of the cellular grade of structure was attended with the most momentous consequences.

In the first place, let me draw your attention to certain remarkable phenomena of life about which I have said nothing so far. In all forms of the higher visible world of living things we find universally, in animals and plants alike, the existence of sex and sexual differentiation. The essential feature of the sexual process, throughout the whole series, is the production by each individual, male or female, of peculiar cells, termed gametes, which are set free from the body, or at least from the organs in which they arise. The gametes produced by each sex are very different in size, form and appearance. Their destiny is for a gamete of one sex to unite with one of the other, and then their bodies, and especially their nuclei, fuse completely to form a single cell with one nucleus; this constitutes the sexual act, for which various special words are in general use, such as conjugation, fertilisation, etc., but for which we may employ the general term *syngamy.* As a result of the syngamy of two gametes of opposite sexes, a single cell is produced which is termed the zygote ("fertilised ovum," "oosperm," etc.). The zygote then starts on a process of energetic cell-division, from which there results ultimately a new individual.

Such, very briefly, is the nature of the sexual process, that remarkable phenomenon which moved even so pious a man as Milton to put into the mouth of Adam a speech questioning the wisdom of the Creator in having invented it. When we turn now to the invisible world of the Protista, we find sexual phenomena to be of widespread occurrence. The process in these primitive beings shows only some slight differences of secondary importance from that seen in the higher forms of life. In the first place, since the Protist individual does not consist of more than one cell, and since a gamete is a single cell, we find that in Protista a gamete is an entire individual; such individuals arise from ordinary individuals at certain periods of the life-cycle, and proceed to syngamy. In the second place, the gametes of opposite sexes are sometimes, but not always, visibly different from each other. In many cases the microscope can reveal no difference whatever between them, and sometimes they cannot even be distinguished in any way from the ordinary individuals of the species. And, finally, the bodies of the gametes do not always fuse as a whole during the act of syngamy, but sometimes merely interchange portions of their nuclei, which then undergo fusion within the body of each gamete separately. These facts are very interesting as indicating the origin and subsequent course of sexual differentiation, but they do not alter in any way our conception of the nature of the sexual process. Syngamy is a union of two cell-individuals, gametes, which pair, and then their whole bodies, or at least their nuclei, undergo a process of fusion, after which the cell-individual enters upon a renewed lease of reproductive power. Syngamy, in short, is essentially nothing more than a process of intermingling of nuclear substance, chromatin, derived in typical cases from two distinct cell-individuals.

Now when we come to consider the occurrence of sex and syngamy amongst the Protista, we find a curious fact, too remarkable to be a mere coincidence. Syngamy appears to be of universal occurrence in the Protozoa and the unicellular plants, that is to say in all those organisms that constitute what I have termed the cellular grade. Sex-phenomena appear, on the other hand, to be quite absent in the organisms of the bacterial grade. Certain processes of rearrangement of the chromatin-substance in some of the bacterial organisms have been dignified with the name of sexual processes, but they are quite different from the union of two gametes seen in true syngamy.

Much has been written, and many theories have been put forward, to explain the origin and significance of sex. I will only mention one view briefly, that which is put forward by Doflein in his great work on the Protozoa, a theory founded on those enunciated previously by Hertwig and Schaudinn. The gist of this theory is as follows. Living cells are regarded as consisting of two groups of vitally-active substances, the one regulating motor, the other trophic functions. In cell-reproduction by fission these substances are never distributed with mathematical equality amongst the descendants, hence continued reproduction of this kind brings about accumulations of different properties in certain individuals, with, as a consequence, impaired vital activity and reproductive power. Individuals are produced, some of which are richer in stored-up nutriment (female), others in motile substance (male). Since these two kinds of individuals contain aggregations of substances which have intense mutual chemical reactions, they exert an attraction one towards the other; the two individuals tend to unite as gametes, and by their union cell-equilibrium is restored and vital powers renewed.

Hence syngamy is regarded as a necessity for the life-cycle, due primarily to the imperfections of cell-division, and to the consequent loss of equilibrium in the cell-constituents. On this view, the general absence of sex-phenomena in the lowest grade, and its existence in the higher, is readily intelligible. In the bacterial grade, the body, usually very minute, is of extremely simple structure, sometimes scarcely more than a speck of chromatin; in such organisms, inequalities of division, if they occur, can be adjusted easily by the rearrangements of the chromatin-substance already mentioned. On the other hand, with the evolution of the cellular grade, the body is differentiated into at least two parts, nucleus and cytoplasm, and becomes of increasingly complex structure; consequently an exact quantitative and qualitative partition of the body during cell-division is of extremely improbable occurrence, at least until the mechanism of cell-division has reached its greatest perfection. The fact that in the Infusoria, the most complex in structure of all the Protista, syngamy is a frequent event and easy to observe, fits in also with the view that sex-phenomena are in relation to complication of cell-structure; and conversely, the fact that in Protozoa of simple structure, such as the Flagellata, syngamy is rarer and appears only to occur at long intervals in the life-cycle, also receives a simple explanation.

From all these facts and considerations, it appears extremely probable that sex and syngamy in living beings was invented, so to speak, when the cellular grade was evolved from the lower or bacterial grade of structure. And this again is related, in my belief, to another very important property of living things, which I will indicate in brief outline.

In the visible world of living beings, we find universally that organisms are divisible more or less easily into groups which we term species. As pointed out above, scientific and popular opinion are more or less in accord on this point. To define a species is difficult, though to recognise one is in general not so. Some species are more sharply marked off from others, some are less so, and some are of questionable rank, regarded by one naturalist as distinct, by another as a mere variety or race. No one now considers a species as a fixed and immutable entity. Nevertheless, the fact remains that the tendency of living things to separate themselves into species more or less distinct is one of the most constant and universal peculiarities of the organic world. And when we turn to the invisible world of the Protista, we find again the same thing. The species of Protozoa and Protophyta are just as distinct from one another, just as constant in their characteristics, as those familiar to us in every-day life.

What is the bond which unites the individuals comprising a species, and separates them from those of another, though closely allied species? So far as the Protista are concerned, I believe it is nothing more nor less than syngamy, which checks and restrains the tendency of individuals placed under slightly different conditions of life to diverge from one another in character. Without syngamy a species would tend to break up into distinct races and strains, either under the influence of environment or by innate variations (if indeed there be any variations in these organisms not due to environmental influences). Syngamy tends to reduce the individual differences to a common level, by mixing together the characters of divergent strains. If this notion be correct, it follows that there are no true species amongst organisms of the bacterial grade, if it be true that syngamy does not occur amongst them; the so-called species of Bacteria are to be regarded as mere strains, capable of modification in any direction by environmental influences, and without the relatively much greater stability of a true species. Researches that are now being carried on at the Lister Institute and elsewhere, will, it may be hoped, throw light on the question of the mutability of bacterial "species."

From these considerations it is, I think, evident that the passage from the bacterial to the cellular grade was perhaps the most important advance in the evolution of living beings. The acquisition of the cellular type of structure was the starting-point for the evolution, not only of the higher groups of the Protista, such as the Protozoa and unicellular plants, but through them of the whole visible every-day world of animals and plants, in all of which the cell is the unit of structure, and which consist primarily of aggregates of cells. Further, with the cellular type of structure were initiated, in my opinion, two of the most universal and characteristic peculiarities of living beings, namely, the phenomena of sex and the tendency to segregate into species.

In the present state of our knowledge it is necessary to proceed with extreme caution in attempting to deal with a group of organisms in which so much remains to be discovered as in the case of the Protista. I venture to bring forward these views with the object of stimulating discussion and criticism, and of indicating lines of inquiry that may be fruitful, and I desire to direct attention to a standpoint from which it may be possible in the future to survey the Protista, and perhaps to bring them under a comprehensive and natural scheme of classification.

WATER-BEARS, OR TARDIGRADA.

(SUPPLEMENTARY NOTES.)

BY JAMES MURRAY, F.R.S.E., F.Z.S.

(*Communicated by D. J. Scourfield, March 28th,* 1911.)

PLATE 8.

SOME years ago I contributed to this Journal (Ser. 2, Vol. X., April, 1907, p. 55), on the suggestion of Mr. Scourfield, a short account of the Tardigrada, intended to help beginners in the study of this interesting but long-neglected group of animals.

Since that time there has been considerable progress made in the knowledge of the Water-Bears. A great many species have been discovered, but these will not concern us much here. Several new genera have been described, most of which are marine.

It is proposed now to supplement the earlier paper by giving an account of these new genera, and figuring them.

NAMES OF WATER-BEARS.

Some changes are to be noted in the nomenclature of the Water-Bears. Since my previous paper they have even lost their long-familiar name of Tardigrada. Prof. Hay (**10**) has shown that they have no right to it, as it was stolen from a group of vertebrate animals which had the prior claim. The scientific name of the group is now—Family XENOMORPHIDAE Perty (**26**). The old name is used here, in a popular way, partly for the sake of consistency. I consider, at the same time, that the group is of higher rank than a family, and I propose now to name it Order ARCTISCOIDA, Family XENOMORPHIDAE. The name Arctiscoida was proposed by Schultze in 1861 (**51**) as a family name.

Minor changes of names have occurred—the name *Lydella* being preoccupied, Prof. Hay has renamed it *Microlyda*—and some species have been altered as they became better understood, but we need not trouble about them.

ADDITIONAL GENERA.

The genera to be described which were not noticed in the earlier paper are four in number. Three of them have been discovered since 1907; one was described before but was overlooked for a long time. The new genera are *Tetrakentron* Cuénot 1892 (**2**), *Halechiniscus* Richters 1908 (**40**), *Batillipes* Richters 1909 (**45**), *Oreella* Murray 1910 (**25**). I shall not attempt very full descriptions of these genera, as they are figured, and a good picture conveys more than much writing.

Genus **Tetrakentron** Cuénot (**2**) (Pl. 8, Fig. 2).

Resembling *Echiniscus*, but without plates. All the processes on head and body are short palps or spicules, except one longer hair on each side, at the base of the fourth pair of legs. The head is truncate, and bears on its anterior margin three small palps, one of them in the middle line. At the base of the head, on each side, there is a short spine with a palp at its base, corresponding to seta *a* of *Echiniscus*. There is a spicule at the base of each leg. Each leg bears four equal and similar claws, curved, widely separated from one another, and not borne on papillae or "toes" as in *Halechiniscus* and *Batillipes*. The figures show teeth, gullet and pharynx as in *Echiniscus*, and no eyes. The body is dorso-ventrally flattened. Marine.

The animal is parasitic on the holothurian *Synapta*. It is the only instance of a parasitic water-bear known. It is easily recognised from its peculiar habitat and the characters given. While resembling *Echiniscus*, it has no plates, and the processes on the head are greatly reduced. The median palp on the front of the head is not known in any other water-bear.

Genus **Halechiniscus** Richters (**40**) (Pl. 8, Figs. 3*a*, 3*b*).

Like *Echiniscus*, but without plates. The processes on the head are well developed, but the palps near the mouth are lacking. The seta *a* at the base of the head is thick, and the process at its base, a palp in *Echiniscus*, is elongated—both these processes spring from a common papilla, as in *Batillipes* and *Oreella*. The body bears lateral hairs, corresponding to *c*, *d* and *e* of *Echiniscus*. The legs are jointed and telescopic, the last joint very slender. Each leg bears four narrow toes, terminating in short curved claws.

The teeth, gullet and pharynx are similar to those of *Echiniscus*, but the teeth are connected with the gullet by *bearers*, as in *Macrobiotus*. There are no eye-spots. Marine.

While most like *Echiniscus*, the teeth-bearers and unarmoured body mark an approach to *Macrobiotus*, the seta *a* and its well-developed basal palp, both raised on a papilla, show a resemblance to *Oreella* and *Batillipes*, and the slender legs recall *Microlyda* (= *Lydella*).

Genus **Batillipes** Richters (**45**) (Pl. 8, Figs. 4*a*, 4*b*).

Like *Echiniscus*, but unarmoured; with well-developed head-processes, but lacking the palps near the mouth. The striking peculiarity of the animal is that it bears on each foot five slender toes of unequal length, each ending in an expanded, somewhat spoon-shaped body, the modified claw. The toes spring from a very slender terminal joint of the leg. There are no eyes. The body is plump and hyaline, colourless except the stomach. The skin is finely papillose. The teeth, gullet and pharynx are as in *Echiniscus*. The seta at the base of the head (seta *a* in *Echiniscus*) is elevated on a papilla, from which springs also the very largely developed palp. Richters' figures (**44**, **45**) show a stout lateral spine (= *e* in *Echiniscus*), and on the fourth leg a fine hair. Marine, among Fucoids, near Kiel.

The remarkable modified claws and the unusual number of five on each foot easily separate this genus from all other water-bears. The arrangement of the cirri on the head, and especially the elevation of *a* and its palp on a conical process, are as in *Halechiniscus* and *Oreella*; the possession of "toes" indicating further affinity with *Halechiniscus*.

Genus **Oreella** Murray (**25**) (Pl. 8, Figs. 1*a* to 1*c*).

Like *Echiniscus*, but without plates. The body is soft, as in *Macrobiotus*, and is papillose dorsally. All the processes on the head correspond to those of *Echiniscus*. The seta *a* at the base of the head and the palp at the base are elevated on a common papilla. The palps near the mouth are very small. There are no eyes. The pharynx and teeth are as in *Echiniscus*, but the teeth have *bearers*, as in *Macrobiotus*. The teeth are relatively very short and the gullet rather wide. There are no processes on the body, except a little terminal median point. The legs are slender and bear four equal and similar curved claws, which are not elevated on "toes" as in *Halechiniscus* and *Batillipes*, but are connected by a slight web at their bases. A moss-dweller.

While nearest to *Echiniscus*, with which it would be united, despite its other slight peculiarities, were it not for the unarmoured body, it shows affinities with several other genera. The soft body and the possession of bearers connect it with *Macrobiotus*. The elevation of seta *a* and its elongated palp on a papilla make an approximation to *Halechiniscus* and *Batillipes*, but it possesses the palps near the mouth, which those genera lack.

Further small differences from typical *Echiniscus* are found in the lack of eyes, and in the thickening of the anterior pair of cirri near the mouth.

In the original drawings (**25**) the enlarged detailed figure of the teeth and pharynx was accidentally omitted, and in consequence of this there was no mention of the bearers in the text. These omissions are remedied here.

One species of *Echiniscus*, otherwise quite a typical member of the genus, possesses teeth, gullet, bearers and pharynx exactly like those of *Oreella*. It was discovered to have these peculiarities by Herr Thulin, of Lund, Sweden, and although I believe the animal to be *E. intermedius* Murray (**25**) the identity is not yet proven.*

ON THE RELATIONSHIPS OF THE VARIOUS GENERA.

The two great types of Tardigrada, the only two which represent extensive groups, *Echiniscus* and *Macrobiotus*, seem sufficiently diverse, while *Milnesium* stands pretty remote from both.

Echiniscus is armour-plated, possesses various setae on the head and commonly on the body; has straight teeth without bearers, and has no chitinous rods in the pharynx. The claws are not joined in pairs.

Macrobiotus is unarmoured, has no setae on the head, usually none on the body; the teeth always have bearers, and there are always chitinous rods in the pharynx. The claws are always joined in pairs.

The two groups differ throughout their whole structure. Recent discoveries of aberrant species in each group have broken

---

* The doubt as to the identity is now removed, as specimens just found (March, 1911) by the Clare Island Survey in W. Ireland possess bearers.

down some of these distinctions, and the new genera established in recent years go further in the same direction.

Echiniscus and *Macrobiotus* remain distinct; the differences have not all broken down, but they do not stand so far apart as was at first supposed. All *Echinisci* are still armoured, and *Macrobioti* unarmoured. All *Echinisci* have still some processes on the head (if only the seta *a*), all *Macrobioti* have none, unless the papillae on the head of *M. ornatus* and *M. papillifer* be regarded as homologous with *a*. All *Echinisci* have disunited claws, similar except for the "barbs," when present; all *Macrobioti* have the claws united in pairs. The other distinctions are not now confined to the respective genera.

Chitinous rods in pharynx.—All *Macrobioti* normally have these, *Echinisci* usually lack them. Some years ago Richters (**36**) noted rods in *E. islandicus*. Any *Macrobiotus* may be found without the rods, but that is only a temporary condition, the "simplex," connected with the moult. No other genus has the rods, except *Diphascon*, and that is very close to *Macrobiotus*.

Tooth-bearers.—Six out of the ten known genera are described as having bearers; no species of *Echiniscus* is said to have them. Quite recently, however, Herr Thulin, of Lund, Sweden, has sent me drawings of a true *Echiniscus* which has bearers. The species is a somewhat aberrant one and agrees very closely with one which I myself described recently, *E. intermedius* (**25**), so closely that, till we have further information on the subject, I must assume that I overlooked this very important character. Making yet another link between *Echiniscus* and *Macrobiotus*, *Oreella* has pharynx, teeth, gullet and bearers precisely like those which Herr Thulin has drawn for the animal which I identify as *E. intermedius*. *Halechiniscus* has "bearers," thus linking *Echiniscus* with *Oreella* by another route.

Setae and palps on the head.—A typical *Echiniscus* has ten processes on the head; near the mouth two pairs of cirri and a pair of blunt palps; at the base of the head a pair of lateral cirri; and at the base of each a small blunt palp. With minor modifications in proportions, these are present in all known species, except *E. cornutus* Richters (**37**) and *E. imberbis* Richters (**42**). In *E. cornutus* seta *a* is modified into a thick curved spine, like a cow's horn; the anterior cirri near the mouth are replaced by little knobs and the posterior pair by thick spines. *E. imberbis* is further modified; the four cirri and palps near the mouth are lacking, so that there only remain process *a* and its palp, characteristic of all known *Echinisci.*

In related genera further modifications take place. In three genera all the processes on the head are reduced to small palps or spicules. *Milnesium* has all six processes near the mouth as palps, and has another pair of similar palps corresponding to *a* of *Echiniscus*. *Echiniscoides* has only one pair of spicules at the mouth, and a pair at each side in the position of *a*. *Tetrakentron* has three small palps near the mouth, one of them medium, and a spicule and palp recognisable as *a* and its palp.

The genera with well-developed cirri are variously modified. *Microlyda* has *a* and its palp normal, the palps, however, relatively large, and only one pair of forked cirri near the mouth. *Halechiniscus*, *Batillipes* and *Oreella* have very similar cirri, all six being present; the palp at the base of *a* is greatly enlarged and elongate, and is borne, with *a*, on the summit of a more or less elevated process. The palp is largest in *Batillipes*. The palps near the mouth are lacking in *Halechiniscus* and *Batillipes*, and are reduced to very small points in *Oreella*.

Processes on the body.—It is not every *Echiniscus* which has processes (spines, setae or knobs) on the body, nor are these processes confined to this genus, still paired processes are eminently characteristic of the great majority of the species. The commonest processes are certain lateral ones, which Richters distinguishes as *b*, *c*, *d* and *e*, and certain dorsal ones over *c* and *d*.

The only genera in which there are no body processes are *Oreella*, *Milnesium* and *Diphascon*. All the marine genera, *Echiniscoides*, *Microlyda*, *Batillipes*, *Halechiniscus* and *Tetrakentron*, have some of the lateral processes corresponding to *c*, *d*, *e*; *e* being the most constantly present.

Species of *Macrobiotus* have the body usually smooth, without processes, rarely papillose. Some half-dozen species have processes, usually small spines or blunt knobs; in *M. ornatus* long spines. Though these processes are paired, they are so numerous in *M. ornatus*, *M. papillifer* and *M. sattleri* that it is hopeless to regard them as homologous with *b*, *c*, *d*, *e* of *Echiniscus* (in *M. polychaetus* the whole body is covered with spines which do not appear to be paired.)

With three other species the case is different. *M. dispar* and *M. ambiguus* may have one pair of blunt knobs, which may be regarded as homologous with *e*. *M. aculeatus* (**25**), an Australian species, has three pairs of soft spines which may well be supposed to occupy the positions of *c*, *d* and *e*, as was first pointed out to me by Prof. Richters in a letter.

The indications of relationship which have been reviewed in the preceding paragraphs are certainly somewhat complex, and not a little conflicting, but nevertheless something may be drawn from them of the possible genesis of the genera and species. The genera cannot be arranged in series; each is linked up with several others.

The time is premature for attempting to trace the genesis—new forms are constantly being discovered which alter our ideas of the affinities—still, some suggestions possible in the present state of our knowledge may be permissible.

It need not be supposed that any genus is directly in the line of descent from the hypothetical primitive tardigrade to the other diverse genera. Reviewing the ten known genera, it appears that most of them have some degree of resemblance to the well-known and extensive genus *Echiniscus*. *Milnesium* and *Macrobiotus*, with its dependent *Diphascon*, are furthest removed.

All the marine genera, and *Oreella*, have the head-processes traceable to modifications of the type of *Echiniscus*, and they further conform to it in the structure of the teeth and pharynx and in having all the claws similar and separate (the barbs of *Echiniscus* itself being only a trifling departure from the uniformity, and the claws of *Batillipes* differ only in size).

As *Echiniscus* is such a greatly preponderant genus among the Echiniscoid genera (all the others possessing at present only one species each), and as they are all highly specialised animals, it may be legitimately supposed that from a dominant type, not unlike *Echiniscus*, these have been derived by modification in adaptation to the peculiar situations in which they now live. *Oreella* is in a rather different position to the others, occurring as a moss-dweller under conditions comparable to those in which the great majority of both *Echinisci* and *Macrobioti* dwell. It may be that *Oreella* can tell us more of the line of descent than any of those more specialised animals. In fact, it stands nearer to *Echiniscus* than any of the marine genera, while yet approaching *Macrobiotus* in the possession of bearers and an unarmoured skin.

Batillipes, in view of its possession of five toes, in an order in which four is almost universal, must be regarded as the most aberrant of the Echiniscoid genera. Eccentricities of this kind are uncommon in nature. When any structures exist in a definite number throughout an order, there is rarely any variation in the number except in the direction of reduction or duplication.

Echiniscoides also departs from the normal number of toes, but in a direction more readily understood, since there is still a tendency to have an even number (8), double that normal in the order.

Microlyda (*Lydella*) has the claws reduced to one on each foot. While it is not difficult to derive such a form as this from the normal type, it has been plausibly suggested that *Microlyda* is a larval form and that the adult might have an even number of claws (two or four).

Macrobiotus is also an extensive genus of water-bears. It even exceeds *Echiniscus* in the number of species contained in it. It is, however, a much less homogeneous genus than *Echiniscus*; it contains large groups of very diverse structure, and will probably have to be broken up even more completely than *Echiniscus.*

Remote though *Macrobiotus* is from *Echiniscus*, there are not wanting signs of affinity, in the rare occurrence among *Echinisci* of bearers, and even of chitinous rods in the pharynx; also in the possession by some *Macrobioti* of processes probably homologous with those of *Echinisci.*

Diphascon stands so near *Macrobiotus* that it has often been doubted whether it could be maintained. The sole constant character is the elongated and flexible gullet, and that is reduced to a minimum in *D. angustatum*, and, moreover, the gullet may be exceptionally elongated in a true *Macrobiotus.* There are two subsidiary characters which confirm my belief in the validity of the genus—there is a definite type of claw, and many species have a very narrow pharynx.

The *Diphascon* claw is not confined to the genus—several *Macrobioti* have it—but its constant association with the flexible gullet shows that these characters indicate a natural group.

SYNOPSIS OF THE GENERA AND SPECIES.

In order to indicate the magnitude of the study which the student has before him when he takes up the Tardigrada, I think it will be well to give a full list of the recognised species, without attempting any diagnosis.

The list of 120 admitted species is not the result of any very careful weighing of the claims of all the reputed species. It includes all the species which I believe to be good, as well as many about the validity of which I am very doubtful, but which I have not been able to study critically.

I see no object in giving at present any list of synonyms and rejected species. Such a list would be quite formidable in extent and would only trouble beginners in the study, unless accompanied by critical notes on specific values, which would be outside the scope of this paper.

Key to the Genera.

1.	With processes (palps or cirri) on the head	2
	Without processes on the head; rods or nuts in pharynx	8
2.	Back distinctly armour-plated	3
	Back not armour-plated	4
3.	Claws four (in the adult)	*Echiniscus.*
	Claws more than four, usually eight	*Echiniscoides.*
4.	With processes (setae, palps or spicules) on the body	5
	No processes except on the head	7
5.	Toes five, bearing spoon-shaped processes, the modified claws	*Batillipes.*
	Claws four on each leg	6
	Claws one on each leg	*Microlyda.*
6.	Head cirri well-developed, short claws borne on finger-like processes	*Halechiniscus.*
	Head processes short palps or spicules, claws not on finger-like processes (parasitic)	*Tetrakentron.*
7.	Four similar claws on each foot	*Oreella.*
	Two slender claws, and two shorter, usually branched	*Milnesium.*

8. Gullet elongated between the bearers and pharynx, flexible . . . . *Diphascon.*
Gullet not elongated and flexible . . *Macrobiotus.*

TABULAR KEY TO THE GENERA.

	Armour-plated.	PROCESS ON HEAD.				CLAWS.				Teeth-bearers.	Rods in pharynx.	Elongated. flexible gullet.	Eyes.
		Number.	Cirri and palps.	Spicules and palps.	*a* and palp elevated on papilla.	Number.	All similar.	Dissimilar.	Borne on toes.				
**Echiniscoides* .	x	6		x		4-9	x						x
Echiniscus . .	x	10	x			4	x			o, x	o, x		x
Oreella . . .		10	x		x	4	x			x			
Halechiniscus .		8	x		x	4	x		x	x			
Batillipes . .		8	x		x	5	x		x				
Tetrakentron .		7		x		4	x						
Microlyda . .		6	x			1	x			x			x
Milnesium . .		8		x		4		x		x			x
Macrobiotus .		0				4		x		x	x		x, o
Diphascon . .		0				4		x		x	x	x	x, o

NOTE.—An x indicates that the genus always possesses the character mentioned at the top of the column where it occurs, and o or a blank space that it never possesses the character. An o and an x in the same column opposite the same genus means that some species have, and others have not, the character. Thus, in *Echiniscus*, one species has tooth-bearers, and one has been reported with rods in the pharynx. In *Macrobiotus* and *Diphascon* some species have eyes, some have not. The other characters are constant, so far as known. *Macrobiotus* may exceptionally have the elongated gullet like *Diphascon*, but it is not normal in any species, but due to some unexplained cause.

The claws of *Echiniscus* on one foot are all equal, free and similar, except that some may have barbs. Those of *Batillipes* are all similar in form, but the toes vary in length.

* *Echiniscoides* has just been found (March, 1911) in W. Ireland by the Clare Island Survey. Irish examples are soft-bodied, not armour-plated, and have 2 pairs of spicules near the mouth, making 8 in all on the head.

ORDER ARCTISCOIDA SCHULTZE (**51**).

Family **Xenomorphidae** Perty (**26**).

1. Genus **Echiniscus** Schultze (**50**).

A. Segments V. and VI. separate.

1. *E. suillus* Ehr. (**6**).
2. *E. novaezeelandiae* Richters (**39**).
3. *E. imberbis* Richters (**42**).
4. *E. bispinosus* Murray (**24**).
5. *E. conifer* Richters (**33**).
6. *E. pulcher* Murray (**25**).
7. *E. victor* Ehr. (**6**).
8. *E. islandicus* Richters (**36**).
9. *E. borealis* Murray (**22**).
10. *E. cornutus* Richters (**37**).

B. Segments V. and VI. joined.

a. No processes except those on the head.

11. *E. intermedius* Murray (**25**).
12. *E. arctomys* Ehr. (**6**).
13. *E. kerguelensis* Richters (**32**).
14. *E. wendti* Richters (**31**).
15. *E. sylvanus* Murray (**25**).
16. *E. viridis* Murray (**25**).
17. *E. elegans* Richters (**37**).
18. *E. reticulatus* Murray (**14**).
19. *E. macronyx* Richters (**42**).
20. *E. bigranulatus* Richters (**42**).
21. *E. spiculifer* Schaudinn (**47**).
22. *E. tessellatus* Murray (**25**).

b. Only dorsal processes on body.

23. *E. gladiator* Murray (**14**).
24. *E. canadensis* Murray (**25**).

c. Lateral processes, spines or spicules only.

25. *E. calcaratus* Richters (**41**).
26. *E. spinulosus* Doyère (**3**).
27. *E. perarmatus* Murray (**24**).
28. *E. crassispinosus* Murray (**24**).
29. *E. spiniger* Richters (**35**).
30. *E. duboisi* Richters (**30**).
31. *E. africanus* Murray (**24**).
32. *E. aculeatus* Plate (**27**).

d. Lateral setae and sublateral spicules.

33. *E. bellermanni* Schultze (**50**).
34. *E. spitsbergensis* Scourfield (**53**).
35. *E. creplini* Schultze (**51**).
36. *E. oihonnae* Richters (**31**).

e. 3 lateral setae (including *a*): no sublateral spicules.

37. *E. granulatus* Doyère (**3**).
38. *E. merokensis* Richters (**34**).
39. *E. longispinosus* Murray (**24**).
40. *E. meridionalis* Murray (**17**).

f. 4 lateral setae; no sublateral spicules.

41. *E. testudo* Doyère (**3**).
42. *E. muscicola* Plate (**27**).
43. *E. filamentosus* Plate (**27**).
44. *E. blumi* Richters (**31**).
45. *E. crassus* Richters (**36**).
46. *E. velaminis* Murray (**25**).

g. 5 lateral setae; no sublateral spicules.

47. *E. quadrispinosus* Richters (**29**).
48. *E. scrofa* Richters (**29**).

2. Genus **Echiniscoides** Plate (**27**).

49. *E. sigismundi* Max Schultze (**52**).

3. Genus **Halechiniscus** Richters (**40**).

50. *H. guiteli* Richters (**40**).

4. Genus **Oreella** Murray (**25**).

51. *O. mollis* Murray (**25**).

5. Genus **Tetrakentron** Cuénot (**2**).

52. *T. synaptae* Cuénot (**2**).

6. Genus **Batillipes** Richters (**45**).

53. *B. mirus* Richters (**45**).

7. Genus **Microlyda** Hay (**10**).

54. *M. dujardini* Plate (**27**)

8. Genus **Milnesium** Doyère (**3**).

55. *M. tardigradum* Doyère (**3**).

9. Genus **Macrobiotus** Schultze (**49**).

A. Eggs spiny or knobbed, laid free.

a. Claws united about half-way (*hufelandii*-type).

56. *M. hufelandii* Schultze (**49**).
57. *M. eminens* Ehr. (**8**).
58. *M. hufelandioides* Murray (**25**).
59. *M. furciger* Murray (**23**).
60. *M. orcadensis* Murray (**20**).
61. *M. anderssoni* Richters (**42**).
62. *M. vanhoffeni* Richters (**32**).
63. *M. islandicus* Richters (**36**).
64. *M. echinogenitus* Richters (**31**).
65. *M. coronifer* Richters (**31**).
66. *M. granulatus* Richters (**31**).
67. *M. crenulatus* Richters (**34**).
68. *M. harmsworthi* Murray (**22**).
69. *M. occidentalis* Murray (**25**).
70. *M. meridionalis* Richters (**43**).
71. *M. montanus* Murray (**25**).
72. *M. polaris* Murray (**25**).
73. *M. ascensionsis* Richters (**41**).
74. *M. annae* Richters (**41**).
75. *M. intermedius* Plate (**27**).
76. *M. crassidens* Murray (**24**).
77. *M. aculeatus* Murray (**25**).

b. Claws diverging from the base or near it.

78. *M. pullari* Murray (**20**).
79. *M. areolatus* Murray (**25**).

c. Claws of each pair very unequal (*macronyx*-type).

80. *M. furcatus* Ehr. (**8**).
81. *M. dispar* Murray (**18**).
82. *M. ambiguus* Murray (**20**).

d. One pair of claws equal, one claw of other pair very long (*diphascon*-type).

83. *M. oberhäuseri* Doyère (**3**).

B. Eggs thick-shelled, with embedded rods.

84. *M. hastatus* Murray (**20**).
85. *M. arcticus* Murray (**22**).

C. Eggs smooth, oval, viscous, laid free.

86. *M. antarcticus* Richters (**32**).

D. Eggs smooth, laid in the skin at the moult.

a. Body smooth, claws diverging from base or near it.

87. *M. tetradactylus* Greeff (**9**).
88. *M. tetradactyloides* Richters (**38**).
89. *M. schaudinni* Richters (**45**).
90. *M. samoanus* Richters (**39**).
91. *M. augusti* Murray (**20**).
92. *M. zetlandicus* Murray (**20**).
93. *M. canadensis* Murray (**25**).
94. *M. micronychius* Joseph (**12**).

b. Body smooth; claws of *diphascon*-type (one very long).

95. *M. lacustris* Dujardin (**5**).
96. *M. murrayi* Richters (**38**).
97. *M. paraguayensis* Richters (**45**).
98. *M. breckneri* Richters (**46**).

c. Body smooth: claws very unequal (*macronyx*-type).

99. *M. macronyx* Dujardin (**5**).

d. Body smooth: claws joined half-way (*hufelandii*-type).

100. *M. rubens* Murray (**21**).

e. Body evenly papillose.

101. *M. annulatus* Murray (**14**).
102. *M. asper* Murray (**17**).
103. *M. indicus* Murray (**21**).

f. Body spinose, or with knobs in pairs.

104. *M. tuberculatus* Plate (**27**).
105. *M. nodosus* Murray (**24**).
106. *M. ornatus* Richters (**28**).
107. *M. sattleri* Richters (**29**).
108. *M. papillifer* Murray (**14**).
109. *M. polychaetus* Ammann (**1**).

E. Eggs unknown.

110 *M. dubius* Murray (**20**).
111. *M. appellofi* Richters (**40**).
112. *M. virgatus* Murray (**25**).

10. Genus **Diphascon** Plate (**27**).

113. *D. chilenense* Plate (**27**).
114. *D. canadense* Murray (**25**).
115. *D. oculatum* Murray (**16**).
116. *D. bullatum* Murray (**13**).
117. *D. alpinum* Murray (**15**).
118. *D. spitzbergense* Richters (**31**).
119. *D. angustatum* Murray (**14**).
120. *D. scoticum* Murray (**13**).

LITERATURE.

This bibliographical list is not a continuation of that published in the previous paper in this journal (**19**). It is an independent list, containing all the works referred to in the text. Although this leads to considerable duplication in the two lists, I think it is better to keep them independent. It is often very awkward for a student, if he finds references in one paper to a bibliography in another, which he may not possess.

1. Ammann, J. Schweitzerischen Tardigraden. Bern, 1908.
2. Cuénot, L. Commensaux et Parasites des Echinodermes. *Rev. biol. du Nord de la France*, V., p. 16, 1892.
3. Doyère, L. Mémoire sur les Tardigrades. *Ann. Sci. Nat.*, Sér. 2, t. 14, p. 269, 1840.
4. Dujardin, F. Mémoire sur un ver parasite, etc. *Ann. Sci. Nat.*, Sér. 2, t. 10, p. 181, 1838.
5. Ibid. Observations Zoologiques. II. Sur les Tardigrades. *Ann. Sci. Nat.*, Sér. 3, t. 15, p. 161, 1851.
6. Ehrenberg, C. G. Diagnoses novarum formarum. *Ber. Verh. K. Ak. Wiss. Berl.*, p. 530, 1853.
7. Ibid. Mikrogeologie, 1854.
8. Ibid. Bestimmung des mikroscopischen Lebens in bis 20,000 Fuss Alpenhöhe. *Abh. K. Ak. Wiss. Berl.* (for 1858), p. 429, 1859.
9. Greeff, R. Naturgeschichte der Bärthierchen. *Arch. für. mikr. Anat.*, II., 1866, p. 102.
10. Hay, W. P. A Bear-Animal renamed. *Proc. Biol. Soc. Washington*, XIX., p. 46, 1906.
11. Heinis, Fr. Tardigraden der Schweiz. *Zool. Anzeig.*, 32, p. 633, 1908.
12. Joseph, G. Arthropoden der Krainer Tropfsteingrotten. *Berlin. entom. zeitschr.*, 26, p. 17, 1882.

13. Murray, J. Tardigrada of the Forth Valley. *Ann. Scot. Nat. Hist.*, p. 160, 1905.

14. Ibid. The Tardigrada of the Scottish Lochs. *Trans. Roy. Soc. Edin.*, 41, p. 677, 1905.

15. Ibid. Scottish Alpine Tardigrada. *Ann. Scot. Nat. Hist.*, p. 25, 1906.

16. Ibid. Tardigrada of the Forth Valley. *Ann. Scot. Nat. Hist.*, p. 214, 1906.

17. Ibid. Tardigrada of the South Orkneys. *Trans. Roy. Soc. Edin.*, 45, p. 323, 1906.

18. Ibid. The Encystment of *Macrobiotus*. *The Zoologist*, p. 4, 1907.

19. Ibid. Water-Bears, or Tardigrada. *Journ. Quekett Micr. Club*, Sér. 2, Vol. X., p. 55, 1907.

20. Ibid. Scottish Tardigrada, collected by the Lake Survey. *Trans. Roy. Soc. Edin.*, 45, 1907.

21. Ibid. Some Tardigrada of the Sikkim Himalaya. *Journ. Roy. Micr. Soc.*, 1907, p. 269.

22. Ibid. Arctic Tardigrada, collected by William S. Bruce. *Trans. Roy. Soc. Edin.*, 45, 1907.

23. Ibid. Encystment of Tardigrada. *Trans. Roy. Soc. Edin.*, 45, 1907.

24. Ibid. Some South African Tardigrada. *Journ. Roy. Micr. Soc.*, 1907, p. 515.

25. Ibid. Tardigrada. *British Antarct. Exped.* 1907-9, *Sci. Reports*, I., p. 81, 1910.

26. Perty, M. Die Familie Xenomorphidae. *Okens Isis* (for 1834), p. 1241, 1835.

27. Plate, L. Naturgeschichte der Tardigraden. *Zool. Jahrb. Abt. f. Syst.* 3, p. 487, 1888.

28. Richters, F. Fauna der Umgegend von Frankfurt-a-M. *Ber. Senckbg. Natf. Ges. Frankfurt*, p. 21, 1900.

29. Ibid. Fauna der Umgebung von Frankfurt-a-M. *Ber. Senckbg. Natf. Ges.*, p. 3, 1902.

30. Ibid. Neue Moosbewohner. *Ber. Senckbg. Natf. Ges.*, p. 23, 1902.

31. Ibid. Nordische Tardigraden. *Zool. Anzeig.*, 27, p. 168, 1903.

32. Ibid. Antarktische Moosfauna. *Verh. deutsch. Natf. Ges.*, p. 236, 1904.

33. Richters, F. Echiniscus conifer. *Ber. Senckbg. Natf. Ges.* p. 73, 1904.

34. Ibid. Arktische Tardigraden. *Fauna Arctica*, 3, p. 495. Jena, 1904.

35. Ibid. Verbreitung der Tardigraden. *Zool. Anz.*, 28, p. 347, 1904.

36. Ibid. Isländische Tardigraden. *Zool. Anzeig.*, 28, p. 373, 1904.

37. Ibid. Zwei neue Echiniscus-Arten. *Zool. Anzeig.*, 31, p. 197, 1907.

38. Ibid. Die Fauna der Moosrasen des Gaussbergs, etc. *Deut. Südpol. Exped.* 1901-3, 9, p. 261, 1907.

39. Ibid. Moosfauna Australiens, etc. *Zool. Jahrb.*, 26, *Abt. f. Syst.*, p. 196, 1908.

40. Ibid. Marine Tardigraden. *Zool. Anzeig.*, 33, p. 77, 1908.

41. Ibid. Moosfauna Studien. *Ber. Senckbg. Natf. Ges.*, p. 14, 1908.

42. Ibid. Moosbewohner. *Wiss. Ergeb. Schwed. Südpol. Exped.* 1901-3, 1908.

43. Ibid. Tardigraden unter, 77°, S. Br. *Zool. Anzeig.*, 34, p. 604, 1909.

44. Ibid. Marine Tardigraden. *Verh. deut. Zool. Ges.*, p. 84, 1909.

45. Ibid. Tardigraden-Studien. *Ber. Senckbg. Natf. Ges.*, p. 28, 1909.

46. Ibid. Tardigraden aus den Karpathen. *Zool. Anzeig.*, 36, p. 7, 1910.

47. Schaudinn, F. Die Tardigraden. *Fauna Arctica*, 2, p. 187, 1902.

48. Schrank, F. von P. Fauna Boica, pp. 178 and 195. Landshut, 1803.

49. Schultze, C. A. S. Macrobiotus hufelandii. *Gratulationsschrift*, Berlin, 1834.

50. Ibid. Echiniscus bellermanni. Berlin, 1840.

51. Ibid. Echiniscus creplini. *Gryphiae*, 1861.

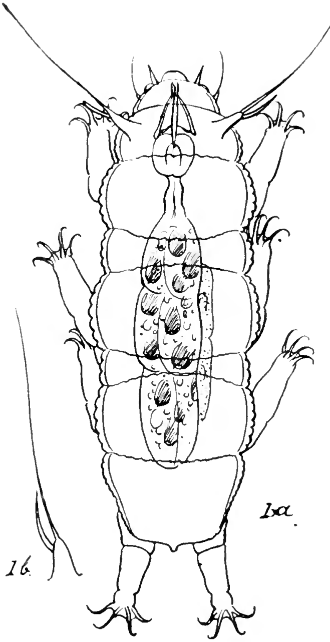
52. Schultze, M. Echiniscus sigismundi. *Arch. für. Mikr. Anat.*, I., p. 428, 1865.

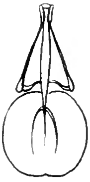
53. Scourfield, D. J. Non-Marine Fauna of Spitsbergen. *Proc. Zool. Soc. Lond.*, 1897, p. 790.

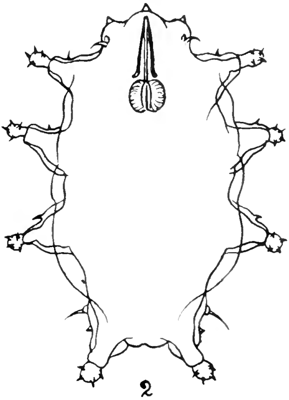
DESCRIPTION OF PLATE 8.

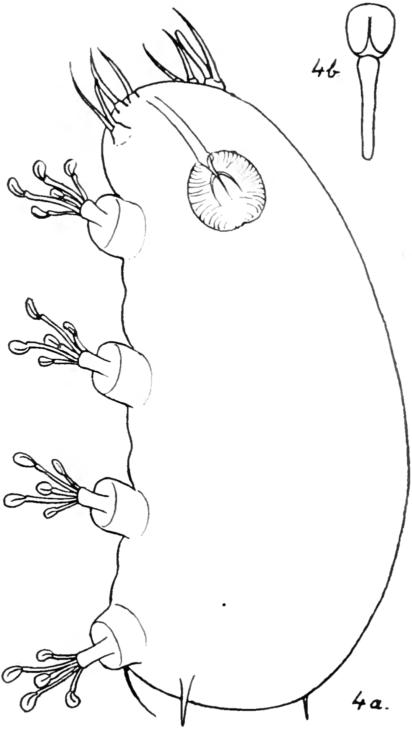
The drawings of the complete animals are all to the same scale, in order that relative sizes may be compared.

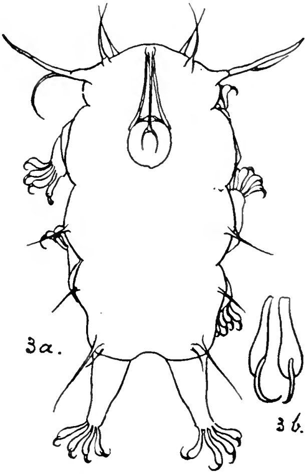
Fig. 1*a*. *Oreella mollis*, dorsal view.
,, 1*b*. *O. mollis*, seta *a* and its palp.
,, 1*c*. *O. mollis*, teeth, gullet, bearers and pharynx.
,, 2. *Tetrakentron synaptae*.
,, 3*a*. *Halechiniscus guiteli*.
,, 3*b*. *H. guiteli*, toe and claw in two different positions.
,, 4*a*. *Batillipes mirus*.
,, 4*b*. *B. mirus*, toe and claw.











J. Murray, *del.*

Tardigrada.

ON SOME NEW DIATOMIC STRUCTURE DISCOVERED WITH A NEW ZEISS APOCHROMAT.

By A. A. C. Eliot Merlin, F.R.M.S.

(*Read March 28th*, 1911.)

The late Dr. Goring said in 1829, "Microscopes are now placed completely on a level with telescopes, and, like them, must remain stationary in their construction. "Happily for us," said Mr. Bowerbank, in his address to the Microscopical Society, February 10th, 1847, "this prediction has not been fulfilled. Admirable as were the combinations alluded to by Dr. Goring, they were very far inferior to those which we now possess, and which we, like the worthy doctor, are, perhaps, inclined to believe are scarcely capable of being surpassed; but however beautiful the combinations around us, let us hope that the same skill and talent which have wrought these great and valuable improvements in the instrument will continue to aid and assist the scientific world by aiming at and achieving a still further degree of perfection."

The above remarks, taken from Quekett's *Treatise on the Use of the Microscope*, published in 1852, remain singularly true and applicable even at the present day, as few, or none, can appreciate better than members of this Club. Thus, in 1899 I obtained a Zeiss $\frac{1}{8}$-in. apochromat of measured N.A. 1·42 and I.M.P. 87. I have reason to know that this objective was then probably second to none in existence, and by its aid many new and interesting observations were effected. However, early in 1910 it came to my knowledge that a further advance had been made in the construction of these lenses, and I therefore obtained an example of the new combination in June of last year. This objective, exactly similar in aperture and power to the older glass, has been found to afford decidedly superior defining power and contrast on delicate objects when employed with a large, sometimes nearly full, working aperture. The first-fruits were obtained with it while examining an old Möller balsam-mounted type-slide, secondaries being noticed in the capped primary perforations of *Doryphora amphiceros* Reitz (*Rhaphoneis amphiceros*

Van Heurck). The diameter of these primaries was afterwards carefully measured and proved to be 0·0001122 in. when corrected for antipoint. Subsequently I re-examined many objects familiar to me with my older objective, particular attention being given to such as possess extremely elusive features just within the grip of that lens. In every case, without exception, the observations previously recorded were confirmed by the new objective, features previously extremely difficult being found comparatively easy, while various new structures, unsuspected before, have been discovered. Amongst these I venture to bring the following to your notice:

Craspedodiscus coscinodiscus. The secondaries of this particular specimen were doubtful until re-examined with the recent lens, which exhibits them quite certainly.

Epithemia turgida. The primaries prove to be irregularly cruciform in shape, somewhat of the Arachnoidiscus type. These require high magnification (about 3,000) and very perfect defining power to properly reveal their true nature and shape.

Cymbella gastroides Kütz. Primaries rectangular in shape, divided and broken up into secondaries.

Gomphonema geminatum Ag. Secondaries closely resembling the foregoing.

Stictodiscus areolatus Grun. (Oamaru). Exhibits a delicate but not particularly difficult network on the lower surface of the valve. A fine dotted structure can be seen on the under edge of the rim of this specimen.

Aulacodiscus Janischii Gr. and St. (Oamaru). This exhibits a very distinct and obvious "veil." Should prove to be within the grasp of most good cheap oil-immersion lenses.

Endictia oceanica Ehr. (fossil, from Peru guano). This possesses easy secondary perforations plainly seen in balsam.

All the foregoing observations were made with working apertures varying between 1·3 and 0·95 N.A. In no instance was oblique light or a smaller illuminating cone employed.

There can apparently be little doubt that few, if any, diatomic valves possessing medium-sized primary perforations have such passages into the interior of the organism unobstructed or unprotected by caps pierced by finer holes. The limit of this capping we are at present unable to discover, but it would seem probable that species possessing very fine primaries, such as the

Naviculaceae, do not require such protection, the diameter of their main perforations not greatly exceeding that of the coarser secondaries in the capped kinds. Mr. Nelson has recently recorded the discovery of similar capping in the "eye-spot" layer, hence it would seem certain that the protection is very necessary to the well-being, or some function, of the organism. But diatoms guard their secrets well, and assuredly hold many surprises in store for the microscopists of the future, as they have done for those of the past. It appears safe to say that the fascination of the diatom will endure as long as the instrument exists which it has done so much to bring towards perfection.

The advantages of the new lens lie entirely in the superior correction of its aberrations, so that it will better stand a large working aperture. In spite of its fine corrections there can be no question whatever that there is still ample room for improvement in the future, the ideal high-power lens being one which would work at full aperture without turning pale, as a few of the best low-power objectives will do at present.

It should be clearly understood that the new Zeiss apochromat was manufactured with no intention of being specially employed on the Diatomaceae. As it bears a higher consecutive number than 700, it may be taken as self-evident that comparatively few of its predecessors have been acquired with a view to diatom work, or have been ever used on a diatom. In practice it has been found to yield the most clear and brilliant definition on such widely differing objects as Karyokinesis in the root of Lilium, various bacteria examined under the highest eye-pieces, and the moving bubbles in the fluid cavities of fluorite. My experience is that the whole series of Zeiss apochromatic objectives, from the lowest to the highest powers, when used with a large working aperture, afford the truest images of all classes of objects. Their use is general throughout all the principal laboratories of the world for utilitarian purposes of the greatest importance, and their employment on diatoms is by no means widespread, or more than a side issue. The late Dr. Dallinger found it necessary to employ similar lenses for the most difficult points in his original researches on the life-history of the Saprophytes. In times past, before lenses of great aperture could be properly corrected, wide-angle glasses were constructed for the express purpose of being employed solely on the Diatomaceae, merely for the resolution of striae with very oblique light; but such lenses would not clearly define any object whatever, diatomic or otherwise, with axial illumination. Experiments with the very considerable number of objectives, of all dates, in my possession, including examples by most of the leading English and foreign makers, have shown me that any lens I have ever seen which, with a large working aperture, affords a clean and brilliant image on one class of object will do so on all. The qualities in an objective, now of prime importance to all investigators, are exceeding sharpness of image and brilliancy of contrast with, at least, a $\frac{3}{4}$ cone. The powers chosen will naturally vary according to the minuteness of the objects dealt with.

After good definition, but fortunately far less essential, flatness of field is desirable, but is seldom ever really attained with a large W.A. During last summer I examined a lens supposed to be strong in this respect, but found that it was not so.

In submitting these remarks for your kind consideration I do so well knowing that differences of opinion exist on the subjects touched upon, but I nevertheless claim your kind indulgence, as my views are the outcome of long practical experience. It is the duty of an observer to state the results of his observations without fear, for divergence of view should not be incompatible with good feeling and friendliness, it being certain that all opinions in scientific matters will eventually stand or fall on their merits.

ON DARK-GROUND ILLUMINATION.

By Edward M. Nelson, F.R.M.S.

(*Read March 28th*, 1911.)

As this kind of illumination is so much in use at the present time, a few notes on the subject may not be out of place. The illuminant is presumed to be a paraffin lamp with a ½-in. wick. Now, the microscope trade differs in a certain way from most others; any one, for example, can buy an original biscuit, soap, cosmetic, or be made very ill by an original quack remedy; but one cannot buy a microscope lamp of the original pattern. The one I designed and have continuously used for upwards of thirty years has been altered and "improved" by various people, some among them being novices who have only had a microscope a fortnight. The luminosity of the light given by one of these "improved" lamps when measured against mine showed a deficiency of no less than 50 per cent, and some are even worse than that. My lamp owed its origin to my method of microscope work, viz. that of viewing the object in a sharply focused image of the flame. When this was done with an old pattern lamp the flame was not only distorted by the imperfect surface of the glass chimney, but was also disturbed by a reflection from the opposite inside surface.

A black metal chimney with the 3 × 1-in. slip was the obvious method of removing both these errors.

One of the early "improvements" was to make the inside of the metal chimney a reflecting surface; another was to put a window at the opposite side with a coloured glass. By these means one or other of the ends for which this form of chimney was designed was defeated.

This prologue is my apology for inflicting upon you a second description of the lamp, as the plan of the original one, owing to its many "improvements," seems to have been forgotten.

Description of Lamp.—The lamp has a paraffin burner with a ½-in. wick. The reservoir is broad and shallow, 1 in. deep inside measurement; shallow in order that the lamp flame may be brought down close to the table, for which reason the burner should be close to the top of the reservoir; and broad so that the heat may be dissipated by the large surface. The surface of my lamp cistern has a total area of over 60 square in., which is equivalent to a cylindrical reservoir of 5·4 in. in diameter, and 1 in. deep. A large quantity of heat is conducted to the reservoir by the metal chimney, so lamps with small reservoirs are absolutely dangerous, as the oil may boil. I have seen this occur in an "improved" lamp; the oil is vaporised and burns with a large flame at the top of the chimney. My lamp is often alight for twelve hours at a stretch, and it has never been known to get hot. Below the reservoir an arm capable of rotation is pivoted, the middle of the flame being in the axis. This arm is slotted, and in the slot a tubular post which carries the bull's-eye rod slides freely. This post has a clamping nut at the bottom to fix it. The bull's-eye rod slides up and down in this tube, and can be fixed at any height by a clamping collar. The reservoir with all this attached to it slides up and down a pillar on a firm foot; it, too, is fixed by a clamping collar. Note, this collar should be above the reservoir and not below it, in order that it may not be covered with drops of oil. The vertical pillar has a slot cut along its whole length, and the tube to which the reservoir is attached has a pin to fit this slot; this keeps the lamp over its foot, for if the reservoir swings round to one side of the foot it is more than likely that the whole thing will capsize. The chimney is made of blackened brass, with a window 1½ in. long and 1 in. wide to take a 3 × 1-in. slip, which should be of the thinnest kind. Rackwork adjustment to the lamp is not only useless, but in the way, for the effect of lamp movement is already slowed down by the magnifying power of the substage condenser; a slower motion than this is not required. If a rack is placed anywhere it should be put to the slotted arm which carries the tubular post of the bull's-eye, to enable the flame to be accurately focused. It is curious that rack work has never been placed where it is wanted, but only where it is not in the least needed.

Method of obtaining a Dark Ground.—It is a painful sight to see microscopists fumbling about with their lamps and microscopes by the half-hour trying to hit off by some lucky chance a proper illumination of their object. Of course there should be no luck nor chance about it. If the apparatus is correct, the proper illumination should be obtained in sixty seconds; if it is not obtained, then the apparatus is at fault, and should be changed. For if the proper method is employed in the first instance the best will be got out of the apparatus, however bad it is, and nothing further can be done by hours of fumbling.

The first adjustment is to place the bull's-eye at right angles to the edge of the flame. The second is to adjust its height so that the horizontal optical axis of the bull's-eye cuts the brightest part of the edge of the flame. The third adjustment is to focus the bull's-eye so that a sharp image of the flame is thrown upon the wall, distant, say, about 5 feet. Having adjusted the bull's-eye to the lamp in this manner, their relative positions must on no account be altered. The brightness of this image will depend upon what the bull's-eye is working at, *i.e.* adopting photographic terminology, *f*/1·4, *f*/2, and so on. The smaller the denominator of this fraction, the brighter will be the image. The doublet of minimum aberration which I designed will be found more useful than an achromatic lens, for the following reasons: First, it is sufficiently aplanatic for all practical purposes; second, it is sufficiently achromatic, as it is made of glass having a very low dispersive power.

An achromatic bull's-eye fails because it is not possible to make a doublet with a sufficiently small denominator. The only form it could have would be that of a hyper-rapid portrait lens. If these are tried one against the other, the difference, if any, would be in favour of the non-achromatic doublet, which would pass more light than the photographic combination, because it works at *f*/1·2, and is therefore more rapid than any portrait lens made.

Place the lamp on the left-hand side of the microscope and at 10 or 12 inches' distance from the mirror; remove substage condenser and objective from the nose-piece; place a low-power eye-piece in the top of the tube. Incline the plane mirror and adjust the height of the lamp so that the bright part of the flame falls centrally upon it. Now incline the mirror so that the full beam is reflected up the microscope tube. From a distance of 6 or 8 inches look at the bright spot of light at the eye-lens. This should be an evenly illuminated bright disc; if it is not, a slight movement of the mirror or lamp will make it so. When this adjustment is completed neither the lamp nor mirror must be disturbed. Replace condenser and object-glass and proceed to the work in hand, centring the substage condenser and focusing it in the usual manner. If an unbroken disc of light has been obtained at the eye-lens, an unbroken disc of light will be focused on the object on the stage by the substage condenser; therefore, when a suitable stop, one not too large, has been placed below the substage condenser, a dark-field of maximum brightness, for that set of apparatus, will be secured.

This method of arranging the lamp, bull's eye and mirror is important, because when any of these new dark-ground illuminators with fixed stops are employed an image of the light cannot be seen, and therefore the microscopist can know nothing about the condition of his illuminating beam; whether, for instance, it is central, or whether the disc of light is not broken by dark areas.

A dark-ground illuminator with a fixed stop should always have a small centring spot engraved upon the surface of its front lens so that the condenser may be centred to the optic axis by means of a low power.

I have to-day seen, for the first time, the flagellum of the tubercle bacillus with a dry lens upon a dark ground. A few months after Dr. Koch's discovery of the tubercle bacillus I recommended this plan of viewing it upon a dark ground to the medical profession. It was exhibited both to this Club and at the Royal Microscopical Society.* Further, I photographed it upon a dark ground and exhibited the photomicrograph upon the screen; but the medical profession said that dark grounds were not used in Germany, so they would have none of them. Now that dark grounds are used in Germany they cannot have enough!

With my new oil-immersion condenser the light obtained in this manner with a $\frac{1}{2}$-in.-wick paraffin lamp (the same one exhibited here scores of times in years gone by) gives ample illumination for observing the tubercle bacillus on a dark ground with a dry $\frac{1}{6}$-in. and a × 42-power eye-piece. The condenser will work with slips of ·8 to 1·2 mm. thick.

A thick diatom, such as *Eupodiscus argus* or *Aulacodiscus*, when illuminated upon a dark ground, was so brilliant with a 5-power eye-piece that I could not stand the light.

In conclusion, with regard to the quality of a dark ground, an object should appear brilliantly illuminated and as it were lying upon a piece of black velvet. There should be no mist or cloudy nebulosity about either the image or the field. If there is, the fault may lie either in the substage condenser or in the objective. It will be found that the correction of some object-glasses may differ very considerably with objects upon a dark ground; for example, a sharp, brilliant lens of about $\frac{1}{8}$-in. focus and about 0·9 N.A., which upon an object on a bright ground would require a tube-length of 160–180 mm.,

---

* *Journ. Q.M.S.*, Ser. 2 Vol. 1, p. 380, and *Journ. R.M.S.*, Ser. 2, Vol. 4, p. 497 (1884).

needed fully 300 mm. of tube before the field became velvety black. Microscopists should therefore be on the look-out for this sort of thing.

With regard to all these new kinds, or rather old kinds revived, of paraboloids and what not, it was my opinion, when formerly they were in vogue, that none of them could compare with an oil-immersion condenser, and that remains my opinion still.

There are many objectives which perform well enough on objects on a bright ground, but on a dark ground the mist remains, adjust the tube-length how you may. The only thing to be done is to put a stop at the back lens and cut down the aperture. This, I understand, is now often done.

I regret not being able to show you the apparatus myself, but you will not lose anything on that account, as Mr. Curties, who made both the new condenser and bull's eye, will kindly exhibit them for me.

Journ. Quekett Microscopical Club, Ser. 2, *Vol. XI., No.* 68, *April* 1911.

NOTE ON *BOTRYDIUM GRANULATUM* (L.) GREV.

By James Burton.

(*Read November 22nd*, 1910.)

Early in October I came across this little plant in immense numbers at the Welsh Harp reservoir, Hendon. The water had been partially drained away. On the right-hand side of the road going from Cricklewood there is normally a considerable body of water which reaches from the road, under the Midland Railway viaduct and some distance beyond. This space was quite drained, except for the narrow stream of the Brent running through it; and on the left of the road there was also a large space of partially dried mud. All this, which must amount to many acres, was a distinctly bright-green colour. I went down to the side of the space, and at once noticed the presence of the Botrydium. I walked round as far as possible on the mud and on both sides of the road; everywhere that I could reach the ground was thickly covered with it. The mud was drier and cracked in some places, and the little plants extended over the edge of the cracks, and were often so closely packed as to leave little space between them, and had thus become misshapen through mutual pressure. I do not think it is particularly rare, but, at the same time, cannot be very common; I have looked for it for many years without success, and during the last two seasons on our Quekett excursions have been careful to search in the most likely places, yet have never found it. It is well known that when it does appear there is almost always, as in this case, a remarkable profusion, and the available area becomes thickly covered.

The plant consists of small green balloon-shaped vesicles of various sizes, from quite small up to about 3 mm. in diameter, so it is hardly microscopic. Below the surface of the mud an extensive root system is produced; the roots branch dichotomously, and extend to a considerable distance, often reaching a length of $\frac{1}{4}$ inch. As the plants grow very thickly, the roots are entangled and interlaced, and the whole plant being of somewhat tender consistency it is difficult to extricate perfect specimens. The upper part when young is filled with protoplasm and is bright green, later the centre becomes more watery; the green is then seen to be due to finely granular chlorophyll. The roots are colourless and filled with watery protoplasm. As to its classification, Prof. West, the most recent authority on fresh-water algae, classes it with a group called the Heterokontae, but with all deference I do not quite see why. All the older books put it among the Siphoneae, and it seems for several reasons to be very appropriately placed there. One of the interesting facts connected with it is that, although of such considerable size, it is unicellular. I suppose that in thinking of a unicellular organism—plant or animal—one usually considers it as something very small and microscopic, but that is not necessarily the case. The Siphoneae are a class grouped together because of the noticeable characteristic that they are all unicellular, notwithstanding which, most of them are of very considerable size. The best-known member of the group is the exceedingly common Vaucheria. There are many species, some terrestrial, constantly found on the damp earth of flower-pots and on damp garden paths, and many species occur constantly in ponds. In these plants, although they reach a length of several inches, sometimes nearly a foot, no dividing walls appear in the filaments, under normal vegetative conditions. Most of the family are marine, and one genus occurring in the Mediterranean—Caulerpa—reaches a length of several metres, and yet is not built up of individual cells. The whole plant is a thallus, though in outward form appearing to possess a stem, with roots and leaves. Similarly in the little Botrydium we have a well-developed system of roots, quite extensive in size (and, of course, acting physiologically as such), and the upper swollen part, together of considerable volume, and yet the whole is not divided—or, rather, built up of separate cells—but has one undivided cavity throughout the whole.

Another point that strikes one is, where was the plant, or in what form did it exist, while the mud on which it is found was covered with water? So far as I know the reservoir has not been drained for many years; and yet almost immediately the water is drawn off, this organism appears in countless thousands over an extensive area. Perhaps the solution of the problem may be found in the method of reproduction. We learn that it has a remarkable variety of ways of increasing in numbers. Dr. Cooke enumerates about seven or eight, with about five varieties, but there is a doubt about the correctness of some of the observations, and, after all, they may be reduced to about four. In the first place, what we may call proliferation takes place as in almost any of the lower plants. A branch grows from the upper part of a root and turns upwards to the surface, there develops a little swelling, which afterwards becomes a separate individual. The most usual and the most prolific method is for the whole plant to become a zoosporangium. The contents divide up into innumerable little round bodies, each containing several chlorophyll corpuscles. If now the plant is submerged it bursts, and the zoospores swim out with the aid of a cilium. They have a provoking habit of doing this during the night or very early morning, so that it is difficult to witness the process under ordinary circumstances. If the plants are situated on ground only moderately wet, they collapse, the wall sinks in, no doubt because the watery protoplasm passes into the root, and a little heap of spores remains on the surface surrounding the hole which had contained the root. By far the larger number of my specimens went this way, and after leaving them for several weeks protected from complete desiccation they remained in the same condition.

Should a mature Botrydium meet with unsuitable conditions above ground while the spores are still unformed, the whole of the protoplasm may retire into the root-portion. Here it breaks up, each fragment surrounding itself with a rather thick wall, and becomes a hypnospore. This may develop in various ways. Dr. Cooke, translating from a foreign author, says: "If removed from the soil and placed in water the cell becomes a subterranean zoosporangium," which does not seem a very clear statement. Or, if a chain of these cells be laid in moist earth, each protrudes a hyaline process which enters the soil, the opposite end becomes elevated and develops into a fresh plant. He also says that when dried these hypnosporangia "retain their power of germination for a year, and when placed in water form zoospores at any hour of the day or night." The zoospores first spoken of germinate on a moist substratum; "in water they never germinate, but come to rest, are surrounded by a double membrane, and lie dormant for months."

Dr. Cooke, on the authority of Rostafinski and Woronin, speaks also of the development of certain spores having two cilia. These conjugate sometimes in pairs, sometimes several together, and produce a body called an isospore, which, after a time of rest, gives rise to ordinary zoospores. But Prof. West says there is good reason for doubting this process. The spores met with in water have at various times been considered definite organisms, and have received such names as *Protococcus botryoides*, *P. coccoma*, and *P. palustris*. All things considered, it is clear there is much concerning this little alga which is at present unknown, including, I am afraid, the exact form in which it exists during the long periods while its habitat is covered with water, preventing the development of what we look upon as the definite plant *Botrydium granulatum*.

NOTE ON THE LARVA OF MANTISPA.

By R. T. Lewis, F.R.M.S.

(*Read January 24th*, 1911.)

The difference between the mature specimens of the family Mantidae and those of the sub-family Mantispidae is not very obvious to the casual observer, whose attention would be at once attracted by the resemblance between the elongated prothorax, the curiously shaped head with its prominent compound eyes, and the remarkable raptorial front legs. These latter consist of a very long coxa, a femur of nearly equal length, armed on the inner side with a double row of sharp spines, and a tibia similarly armed and articulated so as to close down upon the femur in such a way that when closed the spines of the two interlock and render escape impossible to a victim once caught between them. These peculiarities being common to both Mantis and Mantispa, it is not surprising that the earlier entomologists classed them together and placed both in the same order. A more careful inspection will, however, show that there are important differences between them, for whilst the structure of the wings undoubtedly places the Mantis family amongst the Orthoptera, the venation of the wings in Mantispa as certainly determines that it belongs to the Neuroptera. Both are predatory insects, both seize and feed upon their prey in a similar manner; and though imagination has regarded their strange attitude when watching for victims as being devotional, and the idea has been perpetuated by such scientific appellations as *Mantis religiosa* and *Iris oratoria*, the name "Praying Mantis" should in truth be "Preying." It is, however, with the eggs and larvae that the microscopist is chiefly concerned, and when these are considered the difference between the two families is very pronounced. The Mantidae construct a curious capsule or ootheca in which the eggs are laid in symmetrical rows, and are entirely covered in from view, whilst the eggs of Mantispa are laid singly, each mounted on a slender stalk after the manner of those of the Lace-wing fly, *Chrysopa perla*, which is not uncommon in this country. These eggs are white, with a pearly iridescence. As there are said to be about 600 species of Mantidae known, it is of course quite possible that the description of the newly hatched Mantis given in the *Cambridge Natural History* (vol. v. pp. 247-8) on the authority of Pagenstecher, may correctly apply in some instances, it being there stated that " when the young Mantis emerges from the egg it bears little resemblance to the future insect, but looks more like a tiny pupa ; the front legs, that will afterwards become so remarkable, are short and not different from the others, and the head is in a curious mummy-like state, with the mouth parts undeveloped, and is inflexed on the breast. The first ecdysis soon takes place and the creature is thereafter recognisable as a young Mantis." This, however, is distinctly contrary to my own observation. Some years ago a correspondent in Natal sent me the egg-case of a Mantis which he had found attached to a twig ; the packet was about three weeks in the post, and on opening it I found that the eggs had hatched out during the voyage and the box contained not only the egg-case, but about 150 young insects all dead and dried, and looking at first sight not unlike a small sample of tea. They were all more or less damaged through being shaken together, but on examination I found that they closely resembled the adult in nearly all respects except as to size, colour and the absence of wings. The raptorial front legs were fully developed, the head seemed of usual shape with long many-jointed antennae and palpi as in the mature form, and so far as I could make out the mouth parts were the same, and there were certainly no indications whatever that these larvae had ever changed their skins. A specimen of a similar species after two further moults differed only in being larger and somewhat lighter in colour.

As regards Mantispa the case is entirely different. It has already been mentioned that the eggs are laid separately, each being elevated on the top of a slender stalk. Of those received from my friend in Natal, about a dozen hatched out after their arrival here; the larvae were very small and bore not the slightest resemblance in any respect to the perfect insect. In total length they were slightly less than 1 mm.; the head, about 0·25 mm. long by 0·2 mm. wide, bore two simple eyes and was armed with what appeared to correspond to mandibles, projecting forward, and tapering to a point so as to form a piercing rostrum when closed together. The antennae were three-jointed, 0·16 mm. in length exclusive of the terminal hair; the basal joint short; the middle joint about four times as long, slender at its point of attachment to the basal joint but expanding towards the other extremity; the third joint being about half the length of the second, and terminating with a long straight hair of the same length as the three joints together.

The palpi were seven-jointed, their whole length being 0·125 mm.; the basal joint being slightly larger than that of the antennae, the second joint about the same length but much more slender, the next four quite short and of equal width, and the last slightly longer and tapering to a point. Of the three thoracic segments the prothorax is much the shortest, the meso- and metathorax being about twice its length. The nine abdominal segments gradually decrease in diameter towards the posterior extremity of the body, which terminates in a scoop-shaped plate extending from the anal orifice. The six legs are of equal size and shape, 0·3 mm. in length, the tarsi being very remarkable in that they do not terminate with the usual claw or claws, but with a hollow trumpet-shaped appendage the use of which is not very apparent.

The subsequent history of this larva is of extreme interest, since it affords a conspicuous example of what Fabre has termed hypermetamorphosis. On leaving the egg it is said to bore its way into the ovisac of a spider and to feed upon the eggs or young until it has changed its skin a second time; it then becomes completely altered in appearance, the legs disappear, the head is reduced in size and loses its antennae and other prominent features, the body becomes thickest in the middle, and the larva is converted into a comparatively helpless fleshy grub, which when mature spins a silken cocoon in which its transformation to a nymph takes place. It then emerges from the cocoon, makes its way out of the egg-bag of the spider, and then begins to resemble the perfect insect as regards the general shape of the head, body, antennae and legs, but is furnished with only rudimentary wings. In this state it continues to feed, until after two more moults it becomes a full-grown neuropterous Mantispa with four membranous wings nearly equal in size, the venation of which varies considerably in different species.

A NOTE ON THE AMICIAN TEST.*

By E. M. Nelson, F.R.M.S.

(*Read January 24th*, 1911.)

The following letter, which I have received from Mr. F. J. Keeley, of Philadelphia, has reference to a balsam-mounted slide in his possession, labelled: "*Navicula Amicii*, Florence, Italy. From Prof. Amici to C. A. Spencer."

A mixed fresh-water gathering, containing a large proportion of typical *Navicula rhomboides*, among which are a few valves under 50 microns in length, which form a class by themselves on account of extreme delicacy and transparency, which in the balsam mount renders all but the midrib nearly invisible. On account of this delicacy they are much more difficult to resolve than would be anticipated from the distancing of the markings. They correspond to varieties which have been described as *Frustulia saxonica, Navicula crassinervis.*

A large majority of the valves are fairly robust and, while extremely variable in size, remarkably uniform in the character of the markings, which are readily resolved into dots with central cone under any fairly good objective of 1·20 to 1·30 N.A. [or an exceptionally well corrected lens of about 1·00 N.A.—E. M. N.], there being scarcely any noticeable difference in this respect between the smaller forms and those of twice the size. As a test they are equivalent to the smaller *Navicula rhomboides* of Möller's 60-diatom test plate.

Measurements of twenty valves follow. These were selected by traversing slide by horizontal movement of mechanical stage and measuring every perfect form that crossed the centre of the field. This method, which I generally follow in selecting objects for measurement, was not altogether effective in the present case, as it resulted in including three out of twenty of

---

* "*Navicula rhomboides* and Allied Forms," *Journ. Q. M. C.*, Ser. 2, Vol. XI., p. 93.

the smaller delicate forms, while the proportion of these on the whole slide is certainly much lower.

Length	132·5	55	100	91	43·5	47·5	91·5	105	93	95	microns
Diameter	22·5	11·5	19	17	10	10	18·5	17·5	19	17	,,
Length	117·5	101	85	87·5	47	101	109	87	125	95·5	,,
Diameter	20	18·5	17	17·5	10·5	18	17	16·5	20·5	18	,,

Measurements of five typical valves of varying sizes.

Length.	Diameter.	Transverse striae in ·01 mm.
117·5	20·5	30
95·5	17·5	29
78·5	16·2	30
68	16·5	30
47	10·7	34

[The mean of Mr. Keeley's measurements of five typical valves reduced to inches.

Length.	Breadth.	Transverse striae in ·001 in.
·0032	·00064	77,800

and $$\frac{\text{Length}}{\text{Breadth}} \doteq \frac{\cdot 0032}{\cdot 00064} = 5 \cdot 0$$

therefore $\frac{78}{5} = 15 \cdot 6$ = English *Navicula rhomboides.*

E. M. N.]

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the meeting of the Club held on October 25th, 1910, the President, Prof. E. A. Minchin, M.A., F.Z.S., in the chair, the minutes of the meeting held on June 28th were read and confirmed.

Messrs. William Douglas, Alexander Robertson and Charles B. Morris were balloted for and duly elected members of the Club.

The list of donations to the Club was read and the thanks of the members were voted to the donors.

The President said it was his duty to report to the Club the death of one of their most valued members, Mr. Walter Wesché. All present had known him very well both as friend and colleague, and all would agree with him in the loss they had sustained by his death. He was well known as an expert in certain branches of microscopy, and had devoted himself more particularly to the anatomy of the Diptera. Shortly before his death he had himself been in correspondence with Mr. Wesché on the question as to whether the larva of the rat-flea was in the habit of sucking blood like its parents—a matter on which they differed in opinion, Mr. Wesché thinking that it did so. He only mentioned this as a reminiscence. He felt sure they would all agree in passing a vote of condolence to the widow and in authorising their Secretary to write on their behalf expressing the Club's sympathy with her in her bereavement.

A paper on "Some New African Species of Volvox," by Prof. G. S. West, M.A., D.Sc., F.L.S., was communicated by Mr. C. F. Rousselet, F.R.M.S. The author said that the paper was largely a report on a number of slides of Volvox recently submitted to him by Mr. Rousselet for examination. They embraced a series of specimens of *Volvox globator*, *V. aureus*, and several other forms of considerable interest. The characters of the two European species, *V. globator* and *V. aureus*, are now very well known, and their specific distinction clearly established. In this connection the work of Klein (1889), Overton (1889), and Hick (1891) was mentioned. The distinguishing features of the two species are for the most part in the sexual organs and ripe oospores, although each species can be definitely recognised by the structure of the vegetative colony. In both species the vegetative (asexual) colonies are globular, and the male colonies ovoid; but in *V. globator* the female colonies are almost invariably globose, while in *V. aureus* they may occasionally be ovoid. There is a third European species, *V. tertius* (A. Meyer, 1896), which is less well known, and can only be regarded as doubtfully distinct. In this species there are no connecting strands between the cells of the adult colony. J. H. Powers in America has recently (1905—1906) described several new forms under the names of *V. spermatosphaera*, *V. Weismannia* and *V. perglobator*. The paper then described two new forms of Volvox. The first, *Volvox Rousseleti*, was collected in September 1905, at Gwaai, in Rhodesia, by Mr. C. F. Rousselet. The second form was *Volvox africanus*, obtained from the Albert Nyanza by Mr. R. T. Leiper in July 1907. When the material was first examined, the form was recorded as *V. aureus*; but Prof. West said that since then he had examined many more specimens, and had found constant characters not in keeping with those of *V. aureus*. The colonies are of approximately the same size as *V. aureus*, but differ in being constantly ovoid or egg-shaped, and in the nature of the daughter colonies.

Several preparations of Volvox, including the two new species, were exhibited by Mr. Rousselet.

The President said this communication by Prof. West was a very valuable one and would doubtless be read with much interest when it appeared in the pages of the JOURNAL. Volvox had been claimed by both zoologist and botanist, each making use of it as a type illustrating a certain grade of evolution and regarding it as their own and looking upon the other as a bore. They were very much indebted to Prof. West, and to Mr. C. F. Rousselet for reading the paper.

A hearty vote of thanks was accorded Prof. G. S. West for his interesting paper.

A paper on "Two New Species of Cassidulina," by Mr. Henry Sidebottom, was read by Mr. A. Earland. As introduction to the paper, the speaker drew a diagram on the blackboard of a Textularia, and said that if we imagine such a form folded down the median line, and then rolled up, we should get something resembling a Cassidulina. The author first described the genus, quoting Carpenter, who states that the genus was established by d'Orbigny in 1826. The first of the new species is *Cassidulina elegans*, the second *Cassidulina decorata*. Both forms were found at one station, H.M.S. *Waterwitch*, S.W. Pacific, station 159, lat. 19° 04′ S., long. 179° 43′ E., 1,050 fathoms. Mr. Earland exhibited several preparations of this genus, including the extremely rare form, *Cassidulina calabra*, Seguenza, and the most extreme type of the helicoid spiral in this genus, *C. clavata*, Brady.

The President, in moving a vote of thanks to Mr. H. Sidebottom for his communication, said the Club was very fortunate in having a paper of this character brought before them, and in having it explained by Mr. A. Earland.

A vote of thanks was given to both Mr. Sidebottom and Mr. Earland.

A paper entitled "A Contribution to the List of Hydrachnidae found in the East African Lakes" was read by Mr. Charles D. Soar, F.R.M.S. The author said that the material on which the paper was based was placed in his hands for examination by Mr. C. F. Rousselet in the early part of 1910. It consisted of three tubes containing Hydrachnids collected during the third Tanganyika expedition, conducted by Dr. W. A. Cunnington, F.Z.S., 1904-5. Each tube represents the collection made from one of the three great lakes, Victoria Nyanza, Tanganyika, and Nyassa. Of the specimens obtained from Lake Victoria Nyanza, it was possible to identify only one species, *Unionicula figuralis*, Koch. From Lake Tanganyika, six pieces were obtained, of which three are new. These are *Neumania papillosa*, *Mideopsis minuta*, and *Hygrobates edentipalpis*.

The President thought all would agree with him that the Club had begun the session extremely well on having three such important and interesting papers brought before them. A vote of thanks was accorded Mr. C. D. Soar for his communication.

Mr. A. C. Banfield exhibited living specimens of *Cristatella mucedo*, abnormally hatched from statoblasts. The usual time of appearance is about the end of February or beginning of March.

Mr. A. E. Hilton exhibited Mycetozoa, sporangium of *Arcyria punicea*, after dispersion of spores (× 20).

Mr. J. Burton exhibited various bacteria from decaying fresh-water sponge. Attention was directed to Zoogloea film, formation of spores, and to a very large species of spirillum.

The Secretary said he regretted to have to announce the death of one of their older members, Mr. C. W. Hovenden, F.R.M.S., who joined the Club in 1874.

At the meeting of the Club held on November 22nd, 1910, Mr. E. J. Spitta, L.R.C.P., M.R.C.S., F.R.M.S., Vice-President, in the chair, the minutes of the meeting held on October 25th were read and confirmed.

Messrs. R. J. Gladstone, M.D., A. W. Harris, M.R.C.S., W. G. Garner, G. W. Watts, the Rev. M. Davidson, G. H. Mummery and H. Jewell were balloted for and duly elected members of the Club.

The Secretary mentioned that a letter of thanks had been received from Mrs. Wesché in reply to the vote of condolence passed at the last meeting.

The list of donations to the Club was read and the thanks of the members were voted to the donors.

Mr. H. F. Angus, on behalf of Messrs. H. F. Angus & Co., exhibited and described a number of microscopes by R. Winkel, of Göttingen, who, he said, enjoyed a high reputation in Germany, although almost unknown in England. He pointed out that the model was more or less of the Continental type, but differing in several important details, as was to be expected in the productions of an old-established firm who had shown their originality in the past by first employing fluorite in the construction of objectives, and in producing an objective with a hyper-hemispherical front lens.

The Chairman said he had had the pleasure of examining most of the objectives of this maker and had found them to be remarkably good, but he noticed that they were numbered, instead of being marked with the magnifying power. This was rather a retrograde step which he was sorry to see taken. He hoped Mr. Angus would use his influence to get this altered. The microscope before him was very heavy and could not well be considered a portable instrument.

The thanks of the meeting were unanimously voted to Mr. Angus for his exhibit.

A paper on "A Water-mite New to Britain—*Neumania triangularis*, Piersig," contributed by Mr. George Plant Deeley, was read by the Hon. Secretary. This genus was formerly called Cochleophorus, and several species are described under this generic name by Mr. C. D. Soar in *Science Gossip*, June 1900. The locality from which Mr. Deeley obtained his specimens was Parkhill, Stourbridge. Both sexes were found.

Mr. C. D. Soar said that this mite had long been known in Germany, though it had not previously been found here. He was glad to know that Mr. Deeley had added a new one to the British list.

Mr. T. B. Rosseter, F.R.M.S., contributed a paper on "A New Species of Avian Tape-worm—*Hymenolepis upsilon*," which in the absence of the author was taken as read.

The thanks of the meeting were unanimously voted to Mr. Rosseter for his communication.

Mr. James Burton read a paper, illustrated with blackboard drawings, on *Botrydium granulatum*. The author said that early in October he came across this little plant in immense numbers at the Welsh Harp reservoir, Hendon. The water had been partially drained away. On the right-hand side of the road going from Cricklewood there is normally a considerable body of water, which reaches from the road under the Midland Railway viaduct and some distance beyond. This space was quite drained except for the narrow stream of the Brent running through it. On the left of the road there was also a large space of partially dried mud. All this area, which must amount to many acres, was a distinctly bright green colour. Investigation showed this to be due to the little Botrydium. Mr. Burton said he had looked for it without success for many years, and during the last two seasons, on the Club excursions, had been careful to search in the most likely places, but had never found it. It is, however, well known that when it does appear there is almost always, as in this case, a very large production, and the available area becomes thickly covered. The plant consists of small green balloon-shaped vesicles of various sizes, from quite small up to about 3 mm. in diameter, so it is hardly microscopic. Below the surface of the mud an extensive root system is produced; the roots branch dichotomously, and extend to a considerable distance, often reaching a length of ·6 mm. Here it breaks up into pieces, each surrounding itself with a somewhat thick cell and becomes a hypnospore. This may develop in various ways. Dr. Cooke, translating from a foreign author, says: "If removed from the soil and placed in water, the cell becomes a subterranean zoosporangium"—which does not seem a very clear statement. Mr. Burton said in conclusion there is much about this little alga which is at present unknown, including the exact form in which it exists during the long periods while its habitat is covered with water, preventing the development of what we look upon as the definite plant, *Botrydium granulatum*.

Mr. R. Paulson said the question really was, does the alga exist all the time, or has it the power of very rapid propagation when conditions are suitable? Referring to the quotations from foreign authors, he suggested that it would be best to go to the originals, as the translator might not have clearly expressed the authors' meanings.

Mr. A. E. Hilton asked for information as to the number of nuclei present, and the nature, composition and thickness of the cell walls. He suggested that Botrydium was possibly distantly related to his own pets, the Mycetozoa.

Mr. Burton, replying, said he understood Mr. Paulson to say that if the organism did exist all these years, we should find it. But we possibly have it in an unrecognised motile form. If it did not so exist, it was very remarkable how it could propagate itself over so large an area in so short a time. A friend had said that it was not common, but when it was found advised him to take a wheelbarrow and shovel. The organisms are multinucleate. The spores are small rounded bodies with a very thin wall, and two, three or four small chlorophyll corpuscles. The spores begin to develop on the day after they are liberated. He suggested that there were a few plants growing at the edge of the water, and that when the draining was commenced the edge of the water, in retiring, drew the spores with it, and so over the whole space as their development continued.

The Chairman, in proposing a vote of thanks to Mr. Burton, said it frequently happened that the discussion following a paper was of as great, or perhaps even more immediate, interest than the paper itself.

The Secretary announced that as the date of their next ordinary meeting was December 27th, and that day had been appointed a Bank Holiday, the Committee had decided that there should be no meeting held on that day. The next Ordinary Meeting of the Club would therefore be held on January 24th, 1911.

Exhibited by Charles H. Caffyn: *Nepheline Basanite*, from Butterton Hall Park, near Newcastle, Staffs. This rock has recently been described by the Geological Survey as worthy of special comment, and is of interest as being the second rock only known in England to contain nepheline.

Extract from Summary of Progress for year 1909 of the Geological Survey (published 1910):

In the northern part of Staffordshire there is a well-known dyke which is exposed in several quarries at Butterton and Swynnerton.

Specimens taken from the centre of this dyke in the quarry in Butterton Hall Park prove to be nepheline basanite in excellent preservation.

The rock consists of olivine, augite, plagioclase, felspar and nepheline. At first glance a microscopic section of this dyke is much like a fresh and rather fine-grained olivine dolerite. The abundant olivine is micro-porphyritic and not easily detected in the hand specimen without the aid of a lens. Purplish-brown zonal augite appears in small eumorphic crystals, but is seldom porphyritic. Minute lathes of polysynthetic felspar are numerous in the ground mass; from their extinction angles and refractive indices they seem to belong to labradorite. In addition to these, a clear transparent mineral with low double refraction and a distinct cleavage fills up the interstitial areas left after crystallisation of pyroxene and felspar. This mineral has the cleavage and refractive index of nepheline, and stains readily; it is entirely undecomposed, and in this respect no other nepheline-bearing rock in Britain can compare with it.

For a long time the Wolf Rock phonolite has been the only English rock which is known to contain nepheline, and the addition of a basic type is of some interest. The Wolf Rock is generally considered of Tertiary age; the Butterton dyke has a north-north-west trend and cuts and bakes the Keuper

Marls. It must be post-Triassic, and may with much probability be regarded also as Tertiary.

At the meeting of the Club held on January 24th, 1911, Prof. E. A. Minchin, M.A., F.Z.S., President, in the chair, the minutes of the meeting held on November 22nd, 1910, were read and confirmed.

Messrs. Samuel Bridge, George R. Wynch and Thomas W. Butcher, F.R.M.S., were balloted for and duly elected members of the Club.

The list of donations to the Club was read and the thanks of the members were voted to the donors.

The Secretary said that at the next meeting, which would be the forty-fifth Annual Meeting of the Club, they would be called upon to elect officers and members of Committee for the ensuing year. The Committee had nominated as President, Prof. E. A. Minchin; as Vice-Presidents, Sir Ford North, Messrs. Rousselet, Spitta and Scourfield; and the other officers the same as at present. Four members of the Committee, Messrs. J. M. Allen, Holder, Bryce and Gardner, retired by rotation, and the members were asked to nominate four of their number to fill these vacancies. Mr. Allen and Mr. Holder had intimated their desire not to be re-elected.

The following nominations were then made :

Mr. Bryce,	proposed by	Mr. Rousselet,	seconded by	Mr. Sheppard.
Mr. Caffyn	,,	Mr. Wilson	,,	Mr. Bestow.
Mr. Gardner	,,	Mr. Turner	,,	Mr. Taverner.
Mr. Heron-Allen	,,	Mr. Earland	,,	Mr. Soar.
Mr. Offord	,,	Mr. Caffyn	,,	Mr. Martin.
Mr. Wilson	,,	Mr. Davies	,,	Mr. Vogeler.

As Auditor on behalf of the Committee Mr. Inwards was nominated; and Mr. C. H. Caffyn, having been proposed by Mr. Taverner and seconded by Mr. Curties, was elected to represent the Club.

The Hon. Secretary read a note on "The Amician Test," by Mr. F. J. Keeley, of Philadelphia. This is supplementary to a paper by Mr. Nelson on "*Navicula rhomboides* and Allied Forms" read at the June meeting of the Club (Ser. 2, Vol. XI.

p. 93). Mr. Keeley's letter referred to a balsam-mounted slide from Prof. Amici to C. A. Spencer labelled "*Navicula Amicii*, Florence, Italy." It is a mixed fresh-water gathering, containing a large proportion of typical *Navicula rhomboides*, among which are a few valves under 50 μ in length, which form a class by themselves, on account of extreme delicacy and transparency, which in the balsam mount renders all but the midrib nearly invisible. On account of this delicacy they are much more difficult to resolve than would be anticipated from the distancing of the markings.

In a covering note Mr. Nelson discussed the measurements given, and showed that the much-discussed Amician test is certainly the English *rhomboides.*

Mr. C. F. Rousselet, F.R.M.S., described "Three New Species of Rotifera." The first was *Anuraeopsis navicula*, obtained from material collected in 1904-5 by Prof. A. Borgert at Lake Gregory, in Central Ceylon, at an altitude of about 6,000 ft. The size of the lorica is 92 μ only. It is, therefore, one of the smallest species of Rotifera. In naming the second new species, *Brachionus satanicus*, Mr. Rousselet said that the difficulty of finding new and suitable names for new species of Rotifera is becoming more and more acute, and he thought this name might be excused, and that it was not inappropriate for a Brachionus which inhabits the Devil's Lake in North Dakota, U.S.A *Brachionus havanaensis* is described from material collected some fourteen years ago by Mr. A. Hempel from the Illinois River, near Havana. Only two empty loricas were found; total length, including anterior and posterior spines, 282 μ.

The President, in proposing the thanks of the meeting to Mr. Rousselet for his paper, remarked that it was very interesting to have these descriptions of new species, and he thought the Club was very fortunate in having amongst its members an expert so capable of describing them.

Preparations under microscopes and drawings of all three species were exhibited.

Mr. R. T. Lewis read a note "On the Larva of Mantispa," in which, after comparing the families of Mantidae and Mantispidae and illustrating his remarks by reference to a coloured diagram, he described the differences between the two in the course of their development, and gave an account of the life-history of Mantispa as being a remarkable instance of what had been termed hypermetamorphosis. The paper was illustrated by coloured drawings of the eggs and larvae of Mantispa, and by specimens of each exhibited under microscopes in the room.

The President said he was familiar with the appearance of the newly hatched larva, and he agreed with Mr. Lewis that there was no difficulty in recognising it as the young of Mantis. To a certain extent they mimic the young of the black ant, and sometimes run with, and may easily be mistaken for, them in such instances. In the South of France he had seen them eating small green frogs. It was not often one observed insects capturing and eating vertebrates.

Mr. H. Gunnery, of Acomb, York, sent for exhibition a large number of botanical preparations, some especially good sections, showing mitotic figures and various stages of nuclear division, being much admired. The thanks of the meeting were accorded to Mr. Gunnery and also to Mr. C. Baker, who kindly provided the microscopes used.

Mr. Gunnery also sent a number of lantern slides, mostly photomicrographs, some of excellent preparations of Lilium, showing various stages of nuclear division. Another good photograph was of *Empusa muscae*, disease of house-fly—a L.S. of abdomen of fly, showing the fungal hyphae breaking out at the abdominal segments.

Mr. Paulson said he thought some of the slides were of great interest, as for a long time no one knew what became of the secondary nucleus, but slide No. 8 showed them that the secondary nucleus did play an important part in fertilisation. Some very interesting experiments were performed in Toulouse in connection with this subject, and it was studying the effects as regards secondary fertilisation that had led to considerable improvements in maize. He felt that they owed Mr. Gunnery their thanks for sending these slides for exhibition.

Exhibited by Charles H. Caffyn : *Porphyritic vitreous Rhyolite* (*Obsidian*), Sandy Braes, co. Antrim, Ireland. The Rhyolites are volcanic eruptive rocks with the same chemical composition as the plutonic granites. The difference in texture has been caused by the rhyolite cooling rapidly at the surface when extruded as lava, while the granite has consolidated very slowly under considerable pressure.

The section contains many crystals of quartz and a few of felspar (sanidine) in a ground mass of brown glass. This glassy base is of several shades of brown, and has been streaked out by the flowing of the rock while still liquid. The large crystals were formed previous to eruption, as it will be seen that the glass flows round them.

The ground mass is traversed by a series of roughly concentric cracks, which are produced by the contraction of the material when cooling. This is called "perlitic structure," and it will be noticed that it occurred after the flowing ceased, as it crosses the flow lines.

Professor Watts, in the *Q.J.G.S.* 1894, mentions that these fine perlitic cracks sometimes traverse the quartz crystals as well as the glassy base. This will be seen in the crystal under the microscope.

The glassy base is crowded with minute crystals of felspar and dusty material.

The rock is very brittle and difficult to grind.

At the meeting of the Club held on February 28th, 1911, Prof. E. A. Minchin, M.A., V.-P.Z.S., F.L.S., President, in the chair, the minutes of the meeting held on January 24th were read and confirmed.

Messrs. H. F. D. Jacob, H. Sidebottom, W. E. Bartrum, H. Austin, J. Davidson, E. H. Thomas, J. Pullman and J. Ritchie, jun., were balloted for and duly elected members of the Club.

The List of Donations to the Club was read and the thanks of the members were voted to the donors.

Mr. J. N. Bremner exhibited and described a "swing out" substage fitting which would take the optical part of either an Abbe illuminator or an achromatic condenser. The optical part could be swung out and the iris diaphragm left in the optic axis if desired.

The President said that those who had the opportunity of examining this piece of apparatus would no doubt agree that it was not only very beautifully made, but was likely to be very useful to microscopists.

The thanks of the meeting were voted to Mr. Bremner for his communication.

The Hon. Secretary called attention to the death of Dr. James Edmunds, which took place at Brighton on the 15th inst., at the age of 79. He was a very keen microscopist, and it was chiefly to him that they owed a piece of apparatus of great value —the immersion paraboloid. The idea of this was put forward by Mr. F. H. Wenham in 1855, but Dr. Edmunds demonstrated its great value in 1877.

The President having appointed Messrs. A. C. Banfield and N. E. Brown as scrutineers, the ballot for Officers and Committee for the ensuing year was proceeded with.

The Hon. Secretary (Mr. W. B. Stokes) read the Committee's forty-fifth Annual Report. It was considered that the past year was one of marked progress. Forty-six new members were elected. By resignation the Club lost sixteen members, and by death five. The present number on the books is 480, an increase of twenty-five over last year.

The Hon. Treasurer (Mr. F. J. Perks) presented the Annual Statement of Accounts, and the Balance Sheet for the year 1910, which had been duly audited and found correct.

Mr. A. D. Michael moved that "the Report and Balance Sheet be received and adopted, and that they be printed and circulated in the usual way." He was sure all would agree that they showed the Club to be in a very satisfactory condition, and as they spoke for themselves it was not necessary for him to say anything further to recommend them.

Mr. John Pearson having seconded the motion, it was put to the meeting by the President and carried unanimously.

The President, having asked Mr. A. J. Scourfield to take the chair, delivered his Annual Address, dealing this year with "Some Problems of Evolution in the Simplest Forms of Life."

Mr. Scourfield said he was sure that all present would agree that they owed a deep debt of gratitude to their President for his most suggestive and stimulating address. To amateurs like himself who were still "living among the tree-tops" it was very consoling to know upon such high authority that there was so much yet to be done among the lowest forms of life, for it encouraged them to continue to labour for the further efficiency of the microscope and for a fuller knowledge of these forms of microscopical life. He had been particularly interested in their President's remarks with regard to the division of the Protista into a bacterial and a cellular grade, because he had been reading lately an account of a remarkable theory of protoplasm recently put forward by Mereschkowsky. It seemed to him that there were many points of contact between the views to which they had just listened and those of Mereschkowsky, who held that protoplasm was of two fundamentally distinct types, mykoplasm and amoeboplasm, and that these were associated together symbiotically to form the protoplasm found in the majority of organisms. It would be extremely interesting if on some future occasion they could have their President's opinion on this theory. He then called upon the meeting to express a very hearty vote of thanks to Prof. Minchin for his valuable address.

The motion having been carried by acclamation, the President briefly responded by thanking the members for the kind way in which his remarks had been listened to and received.

Mr. J. M. Offord said it was not often they had an opportunity of thanking any of those who had served them so well, and had done such good service in steering the good ship "Quekett" during the year. From the statement they had heard that evening it did not seem likely at present to run upon any shoal, though there was one which he trusted they would never come upon. He had great pleasure in moving that their best thanks be given to their Auditors and Scrutineers.

This motion having been seconded by Mr. W. R. Traviss, was put to the meeting by the President and carried unanimously.

Mr. J. Grundy moved a vote of thanks to the Officers and Members of Committee for their services during the past year —they had safely carried the Club through some stormy times, and the disturbance which they had experienced must have caused them a considerable increase of trouble; he felt sure therefore that they would pass a very hearty vote of thanks to those who had worked so well for them.

Mr. J. N. Bremner had much pleasure in seconding the motion, and whilst thanking these gentlemen for their services, he must congratulate them on the fact that they were now in somewhat smoother waters, and he might also congratulate the members that they were to have the services of so many of them for another year.

The President having put the proposal to the meeting, declared it carried unanimously.

The Hon. Treasurer, in acknowledging the vote of thanks to the Officers and Committee, said on their behalf that they were greatly obliged to the members for this expression of their confidence—they had met with many difficulties during the past year, but he could promise the Club that the Officers would do their best to further its interest in the future.

The President announced the result of the ballot for Officers and Committee to be as follows :

President . . .	Prof. E. A. Minchin, M.A. (Oxon.), V.-P.Z.S., F.L.S.
Four Vice-Presidents	The Rt. Hon. Sir Ford North, F.R.S., F.R.M.S. C. F. Rousselet, F.R.M.S. E. J. Spitta, L.R.C.P., M.R.C.S., F.R.A.S., F.R.M.S. D. J. Scourfield, F.Z.S., F.R.M.S.
Treasurer . . .	Frederick J. Perks.
Secretary . . .	W. B. Stokes.
Assistant Secretary	J. H. Pledge, F.R.M.S.
Foreign Secretary .	C. F. Rousselet, F.R.M.S.
Reporter	R. T. Lewis, F.R.M.S.
Librarian . . .	Alpheus Smith.
Curator	C. J. Sidwell, F.R.M.S.
Editor	A. W. Sheppard, F.R.M.S.
Committee . . .	C. Turner. J. Burton. J. Rheinberg, F.R.M.S. R. Inwards, F.R.A.S. R. Paulson, F.R.M.S. C. D. Soar, F.R.M.S. A. Earland, F.R.M.S. S. C. Akehurst. J. Wilson, F.R.M.S. E. Heron-Allen, F.L.S., F.Z.S., F.R.M.S. D. Bryce. C. H. Caffyn.

GOSSIP NIGHT.

Objects Exhibited and Notes.

(*November 8th*, 1910.)

A. E. Hilton: *Badhamia hyalina*, × 20. Sporangia broken and emptied of spores; showing portions of capillitia in situ, and their attachment to the walls. In its complete state, each capillitium is a network of flat bands, with broad and thin expansions at the angles; it is connected at its extremities with all parts of the sporangium wall.

(*November 8th*, 1910.)

A. C. Banfield: A young colony of *Cristatella mucedo*. This is the same colony that was shown at the meeting of the club on October 25th last, and on which occasion it comprised four zooids. Since the last meeting it has grown continually, and is now possessed of ten zooids. This animal, it will be remembered, was prematurely hatched from the statoblast on October 21st last.

(*November 8th*, 1910.)

Charles D. Soar: Genital area of *Hydrachna geographica*, showing egg in ovipositor.

(*December 13th*, 1910.)

Charles H. Caffyn: *Hornblende Porphyrite*, Cape Royds, Ross Island, South Victoria Land, Antarctic. The Porphyrites are intrusive rocks of intermediate chemical composition, and stand between the plutonic syenites and diorites, on the one hand, and the volcanic trachytes and andesites on the other.

The section shows porphyritic crystals of brownish-green hornblende mostly twinned and plagioclase felspar, in a ground mass of small felspar lathes and acicular crystals of hornblende. There is also a little brown biotite.

The felspar of the phenocrysts has extinction angles of about 16° from the albite twinning, and is probably oligoclase-andesine. Most of the felspar of the ground mass is probably oligoclase.

This rock with others was given to me by Mr. James Murray, who was with Sir E. Shackelton's Expedition to the South Polar regions. The rock was not found in situ, but was glacier-borne by land ice from the south.

(*January* 10*th*, 1911.)

Charles H. Caffyn: *Hornblende Schist*, Aberystwyth, Wales. This is a good example of a schistose rock caused by pressure (Dynamic metamorphism).

It was no doubt originally a plutonic diorite composed of felspar and hornblende with a little iron ore, but the constituents have now been crushed and spread out with a marked parallel arrangement. The streaking out of the iron ore (probably ilmenite) is well displayed, the felspar is broken up and re-crystallised as a mosaic, and the hornblende, which was originally in fairly large-sized crystals, has been fractured and the smaller pieces are elongated in the direction of the vertical axis. Some of the crystals show the process of breaking down.

The ilmenite (titaniferous iron ore) is altering into granules of leucoxene, a variety of sphene.

The rock was not found in situ, but was picked up on the beach. It probably came from one of the schistose complexes of Carnarvonshire or Merioneth.

(*February* 14*th*, 1911.)

Charles H. Caffyn: *Orbicular Diorite*, Corsica. The diorites are plutonic rocks essentially composed of plagioclase felspar and hornblende.

Orbicular texture is one produced by more or less spheroidal aggregations of megascopic crystals embedded in a ground mass, these spheroids being generally characterised by concentric shells composed of one or more of the constituent minerals of the rock.

The section shows a portion of one of the spherules and some of the ground mass.

The central portion of the spherule is granular diorite; the surrounding zones are partly radial crystals of bytownite felspar, and partly felspar and hornblende.

Similar rocks occur in other European localities.

FORTY-FIFTH ANNUAL REPORT.

In reporting upon the Club's welfare during 1910, your Committee is able to congratulate members upon a year of marked progress.

During the year forty-six new members were elected. This number is above the average for the preceding decade, which was a fruitful period in this respect; it is also much higher than the numbers for the two years immediately preceding. By resignation the Club loses sixteen members, and by death five members, leaving a net gain of twenty-five.

Among those removed by death must be mentioned the name of Mr. Walter Wesché, whose activity as author of many valuable papers read at the meetings, and as a member of the Committee, make his death deplored by members of the Club.

The meetings have been consistently well attended even under the trying circumstances involved by the rebuilding of the Club's room, and those members who attended were rewarded by hearing a number of papers of interest and importance. Of these communications may be mentioned:

Feb.	Presidential Address: Some Reflections on the Phenomena of Parasitism in Protozoa . .	Prof. E. A. Minchin.
April.	The Life-Phases of Mycetozoa .	Mr. A. E. Hilton.
,,	Two Instances of the "Breaking of the Meres"	Mr. James Burton.
June.	*Navicula rhomboides* and Allied Forms	Mr. E. M. Nelson.
,,	A New Classification of the Bdelloid Rotifera	Mr. D. Bryce.
Oct.	New Species of Volvox . . .	Prof. G. S. West.
,,	Two New Species of Cassidulina .	Mr. H. Sidebottom.
,,	A Contribution to the List of Hydrachnidae from East African Lakes	Mr. C. D. Soar.

Nov.	*Neumania triangularis*, a Water-mite New to Britain . .	Mr. G. P. Deeley.
,,	*Hymenolepis upsilon*, a New Species of Avian Tape-worm . . .	Mr. T. B. Rosseter.
,,	Note on *Botrydium granulatum* .	Mr. James Burton.

The following lectures were also given :

Jan.	Aquatic Organisms collected on the British Antarctic Expedition .	Mr. James Murray.
March.	Life on a Scientific Cruiser and a Visit to a Whaling Station .	Mr. A. Earland.
June.	Some Arctic Types of Foraminifera found in the North Sea . .	Mr. A. Earland.

Your Committee desires to thank the authors of these communications, and wishes particularly to draw attention to the papers on new species which have become once again a feature of the Journal, also to the important paper by Mr. David Bryce upon a new classification of the Bdelloid Rotifera.

Owing to the rebuilding of the Club's premises the Library and Cabinet have not been available during the greater part of the year. It is hoped that the new arrangements will facilitate the business of these important departments.

To the Library have been added the following publications :

Quarterly Journal of Microscopical Science.
Annals of Natural History.
Botanical Gazette.
Essex Naturalist.
Victorian Naturalist.
Mikrokosmos.
Die Kleinwelt.
Memoirs, Reports, and Proceedings of
  Royal Microscopical Society.
  British Association.
  Royal Institution.
  Geologists' Association.
  Manchester Microscopical Society.
  Manchester Literary and Philosophical Society.
  Royal Institution of Cornwall.

Natural History Society of Northumberland.
Hertfordshire Natural History Society.
Bristol Naturalists' Society.
Botanical Society of Edinburgh.
Glasgow Naturalists' Society.
Croydon Natural History Society.
Indian Museum (Calcutta).
Royal Society of New South Wales.
American Microscopical Society.
Smithsonian Institution.
Academy of Natural Science, Philadelphia.
Missouri Botanic Garden.
Philippine Journal of Science.
Bergen Museum.

also

British Rhizopods (Ray Society).
British Nudibranchiate Mollusca (Ray Society).
British Annelids (Ray Society).
Synopsis of the British Basidiomycetes (presented by the British Museum).
James Murray: *British Antarctic Expedition*, 1907-9; *Biology* (presented by the Author).

There were twelve excursions arranged for the year, which is a larger number than usual. The weather was most unfavourable and indeed caused the abandonment of one excursion, yet the average attendance at the others was 21·2.

Reports of the excursions have appeared in the *English Mechanic*, and give an account of many interesting finds. The latter are sometimes exhibited at the ensuing meeting of the Club, but it is hoped that this practice will become more general and that very interesting finds will be exhibited. The Royal Botanic Society, the East London Waterworks, and the Surrey Commercial Docks have each put the Club under a debt of gratitude for their kindness in allowing members to collect in their enclosures.

Once again the Committee has to thank the editors of the *English Mechanic* and *Knowledge* for the space which they so kindly allow for reports of the Club's meetings. The excellent and prompt reports in the former journal continue to be sent to country members to keep them in touch with the most recent work of their fellows near London.

Your Committee desires to thank the officers of the Club for their services during the past year, and particularly desires to thank the Librarian and Curator for their extra exertions in moving books and slides during the period of rebuilding.

Your Committee feels confident as to the future of the Club. Evidence is constantly being given by inquirers as to the need of such a society as this, and probably the best evidence of the use of such a Club as ours is that of the meetings; and so long as these are enthusiastically attended, there need be no fear of the Club outlasting its utility.

THE TREASURER IN ACCOUNT WITH THE QUEKETT MICROSCOPICAL CLUB

For the year ending December 31st, 1910.

DR.	£	s.	d.	CR.	£	s.	d.
To Balance from 1909	245	6	9	By Rent	18	15	0
,, Subscriptions	165	10	0	,, Expenses of *Journal*	80	8	0
,, Dividends on Investments	12	14	4	,, Postages, etc.	5	9	2
,, Sales of *Journal*	26	14	6	,, Printing and Stationery	6	1	4
,, Sales of Catalogues	1	0	0	,, Attendant	6	3	0
,, Advertisements	14	17	6	,, Petty Expenses	2	6	9
				,, Books, etc.	10	10	7
				,, *English Mechanic*	6	12	4
				,, Balance in hand	329	16	11
	£466	3	1		£466	3	1

INVESTMENTS.

	£	s.	d.
$2\frac{1}{2}$ per cent. Consols	200	0	0
Metropolitan Water Board Stock	100	0	0
Metropolitan Consolidated Stock	100	0	0
$2\frac{1}{2}$ per cent. Annuities, 1905	100	0	0

We have examined the above Statement of Income and Expenditure and compared the same with the Vouchers in the possession of the Treasurer, and have verified the Investments at the Bank of England, and find the same correct.

February 14th, 1911.

RICHARD INWARDS } *Auditors.*
C. H. CAFFYN

FREDK. J. PERKS, *Treasurer.*

OBITUARY NOTICE.

WITHAM MATTHEW BYWATER.

Born 1825; *died* 1911.

It is with great regret we have to record the death of Mr. Bywater, which took place, after a short illness, on March 1st, in his eighty-sixth year. Unfamiliar as his name will be to many of the present members of the Q.M.C., yet we of to-day owe him a deep debt of gratitude in that he was one of its founders, and for four years served as Hon. Secretary. Dr. M. C. Cooke, under date March 7th, writes: "I am afraid that in my last letter I did not express adequately the sense of gratitude which every Queketter must feel to the late W. M. Bywater for his valuable services to the Club as Secretary during the early years of its existence. His business habits and gentlemanly courtesy were in good stead, and he was always at his post."

Dr. Cooke and Mr. Bywater became acquainted half a century ago, before the starting of *Science Gossip*, and they were at that time in the habit of meeting periodically in Mr. Bywater's office at 5, Hanover Square, about once a fortnight, to discuss microscopic subjects and compare specimens. "Our two hours' gossip ended about ten o'clock with a glass of whisky and cigar, but were not continued after the Q.M.C. was started."

Mr. Bywater was at that time manager to Messrs. Wilkinson & Kidd, harness-makers, and lived with his family over their premises at 5, Hanover Square. Mr. Lewis remembers spending two evenings there with Mr. Bywater and Mr. Ketteringham, making out and addressing the tickets for the first Quekett Soirée. Mr. Bywater contributed a short article to *Science Gossip*, February 1865, "A Chapter on Hairs," containing microscopic illustrations, and another article in May on "Pigment Cells," also illustrated; but did not, so far as we can learn, contribute anything to the Proceedings of our Club.

Mr. Bywater retired from the secretaryship of the Club at the

Annual Meeting in July 1869. At the meeting on November 26th, 1869, he was presented with a testimonial consisting of a silver salver and tea-service in recognition of his past services. Mr. Le Neve Foster was President at the time, but the presentation was made by Mr. Arthur E. Durham, who had been President during the two preceding years (an account of this appears in the JOURNAL, vol. ii., p. 26). After this very little was seen of him at the meetings, although he remained a member of the Committee up to the annual meeting in July 1874; but during the interval he occasionally attended the annual dinner at Leatherhead (an institution in those days). Mr. Bywater was elected a Fellow of the Royal Microscopical Society in 1860.

THE USE OF THE CENTRIFUGE IN POND-LIFE WORK.

By D. J. Scourfield, F.Z.S., F.R.M.S.

(*Read April 25th*, 1911.)

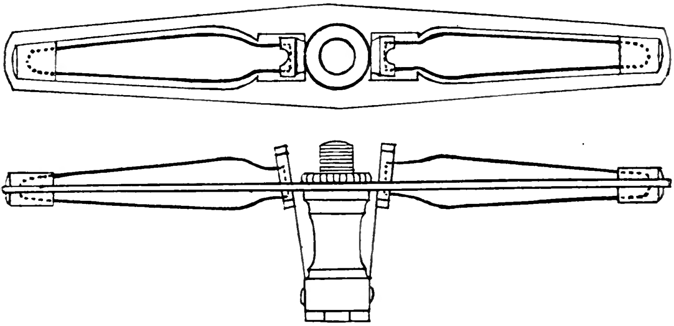
As is very well known, the centrifuge in various forms has long been used in medical work for the sedimentation of certain constituents of blood, urine, milk, etc. It is also pretty generally known that more recently it has been extensively used in bacteriological work and in that vigorous young branch of zoology, experimental embryology. Its use in connection with the investigation of the more minute organisms occurring in the sea and in fresh waters, although not actually novel, is not so well known, and a few remarks on this subject, especially in relation to pond-life work, may therefore be of value.

The application of the centrifuge to the collection of minute organisms in water was apparently first suggested by Cori (**2**) in 1895. Very soon after, Dolley (**4**) constructed a special kind of centrifuge, which he called a Planktonokrit, for the same purpose, and almost simultaneously Kofoid (**6**) and Field (**5**) were also experimenting in a similar direction.

During the next ten years or more, however, the method was not at all widely adopted, probably because it was looked upon merely as an alternative to the more usual and in many respects more simple and convenient methods of concentration by means of fine gauze nets, filter papers and settling tubes. It was not, in fact, until Lohmann (**7**) in 1908 published his splendid paper on the determination of the absolute quantity of plankton in sea water that it was realised that the centrifuge was indispensable so far as the minutest forms of plankton were concerned, and that it was therefore not to be regarded as a substitute for the other methods of collection, but rather that it had its own proper place side by side with them. The necessity for the employment of some more effective means than any of those hitherto in use for collecting the smallest organisms was suggested to Lohmann by his observations on the Appendicularia. He found that these creatures, owing to the exquisitely fine filtering apparatus with which they are provided, were able to secure enormous numbers of very small protists in water which yielded but slight evidence of the existence of such forms when tested in the usual way. He therefore sought for some new method of concentrating these organisms and luckily hit upon the centrifuge as the best appliance for the purpose. Lohmann undoubtedly deserves the credit for this demonstration of the real value of the centrifuge in plankton work, namely, for the concentration in an uninjured state of the smallest organisms; and since the issue of his paper the instrument has been coming more and more into use in investigations on the minute life of the sea and fresh waters. As regards the latter it may be mentioned that immediately after the publication of Lohmann's paper, Woltereck and Ruttner took up the matter at the Lunz Fresh-water Biological Station, and have recorded some preliminary but extremely interesting results in the *Internationale Revue der gesamten Hydrobiologie und Hydrographie* (**10** and **11**). Some suggestive observations on the periodicity of the "centrifuge plankton" in relation to the "net plankton" have also been published in the same periodical by Brehm (**1**).

Coming now to the actual methods of work with the centrifuge, it is most important to note first of all that the samples of water to be tested should be taken directly from the pond or other piece of water into the collecting-bottle without the intervention of any net or other filtering appliance. If this is not done, a wholly false impression of the relative abundance of the minutest forms in comparison with the other microscopic organisms will be obtained, owing to the fact that the vast majority of the former will either pass through the meshes of the filtering material or else be damaged beyond recognition on the filtering surface. Neither should any preservative be added to the water, as it is practically certain that many of the very minute animal forms at any rate, are extremely sensitive to even small traces of alcohol, formalin, etc., and are apt to disintegrate upon the slightest provocation. It follows, therefore, that to get reliable results nothing but the plain pond water in its natural condition should be used, and, needless to say, it should be centrifuged without delay while all the organisms are still alive.

As regards the amount of water necessary, Lohmann showed that quite small quantities were sufficient for obtaining a fairly accurate idea not only of the various kinds of smaller organisms present but also of their relative numbers. He seems to have worked usually with tubes containing 15 c.c. (= about ½ oz.), but sometimes, owing to the great abundance of the organisms in particular samples, he found it advisable to take no more than 3 c.c. for centrifuging. In my own experiments, working mainly with water from small lakes and ponds, I have even reduced the amount still further; for I find that with tubes holding only $1\frac{1}{2}$ c.c. I can usually obtain sufficient deposit to permit of qualitative investigation, though not perhaps sufficient in all cases for accurate quantitative work. The fact that such small quantities of water scarcely ever fail to yield appreciable results points to the conclusion that the very minute organisms, ranging in size from about $\frac{1}{1000}$ in. down to the smallest bacteria, are practically always present in very considerable numbers in the waters of lakes, ponds, etc. In large deep lakes and in the open sea the abundance is not likely to be so great, and rather larger quantities of water will be necessary.



Plan and elevation of "haematocrit" head adapted to carry small vase-shaped tubes holding about $1\frac{1}{2}$ c.c. Two-thirds actual size.

In the centrifuging process itself there are two important questions to be considered, namely, the speed of the centrifuge and the length of time it must be kept running. In a general way it is probably true that a low speed for a long time will be as effective in concentrating the organisms at the far end of the tubes as a high speed for a shorter time. In practice, however, I believe, from my own experience, that there are some organisms which will remain suspended in the water for an almost indefinite time if the centrifugal force does not reach a certain amount, and in order to concentrate these it is absolutely necessary to run the centrifuge at a great speed. Now, for those who, like myself, have to depend upon manual power to work their centrifuge, the only way to obtain really high speeds is to cut down the revolving head to the smallest practicable dimensions so as to reduce as much as possible both the weight and the air resistance. The means by which I have done this is by having the "haematocrit" head supplied with all two-speed centrifuges, somewhat altered so as to take elongated vase-shaped tubes holding no more than about 1½ c.c. With such a head, speeds up to 10,000 revolutions per minute can be obtained, but the highest speed obtainable without too great an effort is about 7,000 revolutions per minute, and this is the rate I usually employ when desiring to concentrate as nearly as may be *all* the organisms present in the water. At this speed a run of from one to two minutes seems to be sufficient for the purpose. Of course very many, perhaps the majority of the organisms, even of the smaller kinds, are deposited at lower speeds, and I have found it useful sometimes, first of all to centrifuge samples of water in the larger tubes usually supplied (holding about 15 c.c.) at a comparatively low speed, and then to pipette off some of the clearer water into the smaller tubes for more rapid rotation with the high-speed gearing. This has the great advantage of separating to a considerable extent the larger from the smaller of these tiny organisms and so rendering the examination of the latter more easy. It would probably be a good plan in every case to subject a sample of water to a second centrifuging at as high a speed as available.

Two little practical points may be mentioned here in connection with the centrifuging process. One is that a very cheap and convenient protective cover for the centrifuge may be made from a common round wooden cheese-box turned upside down. A portion of the lower part of the side must of course be removed to admit of the handle being turned, and a central hole should be cut in the top, so that the box may be placed concentrically with the spindle of the centrifuge. The other point is that in using the small tubes on the "haematocrit" head they should be over-filled with water in the first instance, in order that, when placed in position with the open end resting against the rubber disc, they may be quite full without any air-bubbles.

The best method of removing the centrifuged organisms from either the large or small tubes is to pipette off all the water except a very small drop at the bottom, and then to suck up this remaining drop and forcibly expel it several times. It is very necessary to carry out this alternate sucking up and expulsion a few times, as practically all the organisms that have been thrown down are, immediately after the centrifuging at any rate, forming an actual deposit on the glass, and therefore require to be detached by the application of a little spray of water. In the case of the small tubes these operations are most easily performed with a Rousselet "thistle-head" pipette drawn out to a very fine point.

Obviously the next thing to be done is to transfer a portion of the drop of water, or the whole of it if very small, to a glass slip, live-box, or compressor. As it is desirable, in order to get the best results with high-power objectives, that the film of water to be examined under the microscope should be as thin as it is possible to make it, only a very small quantity of water is required. At this stage a further concentration of the organisms can easily be carried out if necessary by taking a drop of water two or three times larger than that actually required and allowing it to evaporate to the desired size. In any case it is advisable to allow the drop to stand a few minutes before spreading it out with the cover-glass, as some at least of the organisms settle to the bottom and so do not escape so easily to the margins when pressure is applied to the cover-glass.

Having now disposed of the purely technical details connected with the use of the centrifuge in the examination of pond and other waters, it may be well to consider briefly some of the results so far obtained. As regards the little organisms themselves it is found that they are mainly representatives of the bacteria, schizophyceae, desmids, diatoms and chlorophyceae among the plant types, and heliozoa and flagellates among the animals. With the exception of the bacteria all the forms constituting the genuine "centrifuge plankton" are among the smallest examples of their respective groups, and it is somewhat of a revelation to those who have only collected pond-life with nets to observe what a number of excessively small species, even of such well-known groups as the desmids and diatoms, are to be found living in suspension in the open waters of our lakes, ponds and ditches. In harmony with this mode of life many of the species, especially when non-motile, are provided with long delicate spines or other out-growths, or are themselves of a very attenuated form, which is especially the case with the desmids and diatoms. It is somewhat difficult at present to name all the different kinds of organisms which occur in collections made with the centrifuge, as comparatively little attention has yet been given to these very small forms. I have seen quite a number of organisms which are new to me, and, although I cannot be sure that they are really new, I believe that almost certainly some of them have never been named. Very probably some may prove to be immature forms or special stages in the life-history of somewhat larger organisms.

The application of the centrifuge to the investigation of lakes and other fresh waters has already thrown considerable light on various hitherto obscure phenomena. For example, at the Biological Station at Lunz, in Austria, it had long been observed that the plankton Daphnias of the upper and lower lakes, although belonging to the same species, were in much better condition in the former than in the latter, in spite of the fact that the small plankton algae, etc., obtained by the usual net methods, and on which the Daphnias were supposed to feed, were actually more abundant in the lower than in the upper lake. It looked very much like a case which might possibly support the idea of Pütter, that aquatic animals get some at least of their nourishment direct from organic compounds dissolved in the water. When the water was centrifuged, however, it was found that the explanation of the difference was very simple, for it was at once observed that the *very* minute organisms were far more plentiful in the upper than in the lower lake. Thus there was no necessity for any extraordinary hypothesis as to how the "Obersee" Daphnias obtained their extra food.

Arising out of this experience, Woltereck **(11)** was led to investigate the question of the natural food of Daphnias and similar creatures, and he was able to prove experimentally that it really was the extremely minute forms of algae, etc., which counted most in this connection. He fed his Daphnias on pure cultures of small algae of various sizes, and found that the animals thrived better on the excessively minute forms than on the forms which had formerly been considered to be the principal source of their food.

These results very obviously explain the fact known to all experienced "pond-hunters," that in order to keep alive any special captures, and in fact microscopic aquatic animals generally, it is better to place them in water taken from their own pond rather than in ordinary "tap" water. Hitherto there has been no certain basis for this empirical rule, but now it is seen to find its justification in the fact that the special food of the animals is no doubt present in the pond water in the form of extremely minute algae, flagellates, diatoms, etc.

By the help of the centrifuge it is even possible to increase the amount of food material normally present in pond water, and in this way to rear such creatures as Rotifers, Entomostraca, etc., much more certainly and rapidly than before. This is especially true of the plankton forms which have hitherto resisted nearly all attempts at cultivation in captivity. When supplied, however, with their proper food obtained by centrifuging the water of the lake or pond in which they lived, it is found that they can be kept in confinement almost as easily as the hardier littoral species, a fact which will evidently be of great value in various researches on these very interesting forms.

In conclusion it may be repeated that the principal use of the centrifuge in pond-life work, as in marine plankton work, is not to take the place of other methods of collection such as nets and filters, but to be accessory to them. As such an accessory piece of apparatus the centrifuge has evidently come to stay, and no method of collection depending entirely upon straining or filtering processes can be considered sufficient in the future.

Since the reading of the above, Lohmann has issued another very useful paper on the subject (**9**). He uses the word "Nannoplankton" (*νάννος* = dwarf) as a convenient term for the organisms which are so small as to pass easily through the meshes of the finest nets, and he gives a great deal of very interesting information both as to the method of centrifuging water and as to the results obtained. He particularly insists upon the fact that owing to their great rapidity of reproduction the "Nannoplankton" organisms are of much greater importance than might be imagined from their relative abundance at any one moment, a point of view which is sometimes ignored in considering the available food supply of the larger aquatic animals. A number of "Nannoplankton" organisms (all marine, however) are figured, and the excessive minuteness of the majority of the forms is clearly indicated by surrounding the different groups with an outline of a single opening in silk gauze of the finest texture drawn to the same scale. The paper should be studied by all interested in the matter.

LITERATURE.

1. Brehm, V. Einige Beobachtungen über das Zentrifugenplankton. *Internationale Revue der gesamten Hydrobiologie und Hydrographie*, Bd. III., 1910, pp. 173–7.
2. Cori, C. J. Ueber die Verwendung der Centrifuge in der zoologischen Technik und Beschreibung einer einfachen Handcentrifuge. *Zeitschrift f. wiss. Mikroskopie*, Bd. XII., 1895, pp. 303–6.
3. Dakin, W. J. Methods of Plankton Research. *Trans. Biol. Soc. Liverpool*, Vol. XXII., 1908, pp. 526–31.
4. Dolley, C. S. The Planktonokrit. *Proc. Acad. Nat. Sci. Philadelphia*, 1896, pp. 276–9.
5. Field, G. W. Methods in Planktology. *Tenth Ann. Report Rhode Island Experiment Station.* Providence, R. I., 1898, pp. 120–49.
6. Kofoid, C. A. Plankton Studies. I. Methods and Apparatus, etc. *Bull. Illinois State Lab. Nat. Hist.*, Vol. V., 1897.
7. Lohmann, H. Untersuchungen zur Festellung des vollständigen Gehaltes des Meeres an Plankton. *Wissenschaftliche Meeres-untersuchungen.* Neue Folge, Bd. X., Abteilung Kiel, 1908, pp. 129–370.
8. Ibid. Neues aus dem Gebiete der Planktonforschung. *Naturwissenschaftliche Wochenschrift*, 1908, pp. 801–10.
9. Ibid. Ueber das Nannoplankton und die Zentrifugierung kleinster Wasserproben zur Gewinnung desselben in lebendem Zustande. *Int. Revue d. ges. Hydrobiologie u. Hydrographie,* Bd. IV., 1911, pp. 1–38. (Also issued separately.)
10. Ruttner, F. Ueber die Anwendung von Filtration und Zentrifugierung bei den planktonologischen Arbeiten an den Lunzer Seen. *Int. Revue d. ges. Hydrobiologie, etc.*, Bd. II., 1909, pp. 174–81.
11. Woltereck, R. Die natürliche Nahrung pelagischer Cladoceren und die Rolle des "Zentrifugenplanktons" im Süsswasser. *Int. Revue d. ges. Hydrobiologie, etc.*, Bd. I., 1908, pp. 871–4.

THE WORK OF THE LATE SAVILLE-KENT ON BRITISH HYDRACHNIDS.

By Chas. D. Soar, F.L.S., F.R.M.S.

(*Read May 23rd*, 1911.)

Many years ago, in our old friend *Science Gossip*, there appeared a note asking for collections of water-mites to be sent to a gentleman who intended publishing a Monograph on the Hydrachnidae. This gentleman was no other than the late Saville-Kent, whose work on the Infusoria is so well known to all microscopists. Again, in *Science Gossip* for 1882, in answer to a query by a Mr. J. A. Ollard, there is a paragraph by Saville-Kent, in which he says: "I long since commenced the study of water-mites, and collected within the course of two summers in the neighbourhood of London alone upwards of fifty different varieties. I am now working at the subject again with the view to a Monograph of the British species, and shall hence be indebted to Mr. Ollard, or any other subscribers to *Science Gossip*, for new material or notices of new localities of our indigenous types. For the purposes of study the water-mites—or swimming mites as they may be more appropriately called, all the species being especially adapted for a natatory existence, through the development on their legs of long swimming-hairs—may conveniently be kept in small glass bottles of one- or two-ounce capacity, a bottle relegated to each species, and a small fragment of water-plant such as Ranunculus or Fontinalis being added for the little animals to rest and deposit their eggs upon. Small Entomostraca, Daphnias, or Cyprids should be provided as food every few days, the water-mites, like their congeners the true spiders, being eminently predatory in their habits and requiring a constant supply of living prey. A small label should be affixed to each bottle, indicating the locality and date of capture." I do not know if these requests met with any response;

so little was known about water-mites at that time in the British Isles, that there could not have been many that knew what a Hydrachnid was like. It is more than probable Saville-Kent did not receive any answer to his inquiries. In the latter part of the eighteenth century Müller, the first naturalist to publish a work entirely on water-mites, made a similar request, but he never had any material sent to him. I tried the same experiment, but only received two tubes of Infusoria; no mites were sent. But if Saville-Kent did not get any water-mites sent to him, he certainly succeeded in making a very considerable collection himself.

Owing to the courtesy of Mr. Hirst, of the British Museum (Natural History), South Kensington, I have been permitted to look over and examine all the slides, notes and drawings which Saville-Kent had collected together with the object of one day publishing his proposed Monograph. The mites were mostly collected round London, so the field from which they were collected was not large. But even this small area, compared to the rest of the British Isles, has yielded about one-fourth of the present-known British Hydrachnids. So far, the result was very satisfactory, and it is a pity Saville-Kent did not live to publish the result of his study and collecting amongst the Hydrachnidae. To judge from the work he did he was a trained biologist, having been a pupil of Huxley, which was a very great thing in those days. It could not have been in better hands, and, as far as the water-mites were known in his time, no one could have written on them better. Besides which, at the time the collections were made a large number that Saville-Kent found had not only not been named at all, but never even recorded. If they had been found, they had been mistaken for other species, a mistake very easily made when the available literature on Hydrachnidae was so small. Since then, however, they have all been named and recorded on the Continent, and, with two exceptions only, they have all been recorded for the British Isles by other writers. The collections were begun in 1867, and went on at intervals until 1883; and, with the exception of the notes in *Science Gossip* already referred to, I have only found Saville-Kent's name mentioned in this connection in a list of water-mites in Cooke's *One Thousand Objects for the Microscope*. I do not know whether the few particulars there given were supplied by Saville-Kent himself, but

Dr. Cooke mentions that Saville-Kent had detected nearly forty British species.

The first writer in Britain on water-mites was Dr. Johnston, of Berwickshire, about 1849. The next would be Dr. George, of Kirton Lindsey, who did not begin until about 1881. So if Mr. Saville-Kent had written about them at the time he was collecting, he would have come between the two writers above mentioned.

Besides making a good collection of adult forms, Mr. Saville-Kent had also been very successful in breeding the larvae, many of which were quite unknown in those days. But although he did so well with the larvae, like the writers who came after him he made but little progress with the parasitic stage, owing, no doubt, to the conditions under which they were bred being quite different to the ponds and rivers from which they were taken. As far as we know, all water-mites pass the larval stage as parasites; but it is in only a few instances we know the host in which they take up their abode. The life-history of these minute forms of animal life is the most interesting part to the naturalist; but Nature gives up her secrets very slowly. We know very little more now than Mr. Saville-Kent did at the time he was collecting forty years ago. The life-history of only a very few species is recorded, yet we have over a thousand known to science.

Slides.—The medium used by Saville-Kent for mounting his specimens, and his methods of killing, were given in the note already referred to in *Science Gossip* for 1882. They were as follows: "The adult mites may be killed instantaneously, with their legs extended as in life, by momentary immersion in scalding water; and they should then be mounted in a cell of suitable depth, in either camphor water or a weak solution of, say, one of spirit to four or five of water. Specimens thus preserved by the writer so long ago as fourteen years still retain their pristine form and brilliancy; the scarlets, browns, greens and yellows, chiefly characteristic of this group, being as bright as on the day on which they were mounted. Both the ova and hexapod larvae may be preserved in the same simple medium." There are nearly two hundred slides of Hydrachnids in the collection at the Museum, nearly all mounted in fluid as just mentioned in

Saville-Kent's own notes. A great number were perfectly useless, the medium in which they were mounted having leaked out and dried up. In some the objects were completely hidden by mildew, which had taken the place of the mounting medium inside the cell, and in some cases the covers had become loose and the contents lost. The mounts included adults, nymphs, larvae and eggs. Of the adults I was able to identify forty species. Quite thirteen of these had never even been named until long after Saville-Kent had found them, and all but one of these names were given by writers on the Continent, the exception being *Arrhenurus mantonensis* George, 1903. There were several slides of ova and larvae, many of which were particularly interesting; there were also a few slides of the internal anatomy, some of the sections being very nicely mounted, and in one or two cases stained. The collections were made from a number of places round London, some of which would now be described as within London. The Commons were Barnes, Tooting and Wandsworth. Then there is a Common mentioned between Shepherd's Bush and Hammersmith; I cannot call this Common to mind, unless it is what is known as Brook Green. Other places were Bushey, Kew and Kensington Gardens (Round Pond); also Chertsey, Regent's Canal, Wormwood Scrubs, Hampstead Heath, Kew Dyke (which must be the ditch between the towing-path and the wall of Kew Gardens), Harrow Road Pond, pond near Perivale Church, Acton, and Epping Forest. Several of the collections, particularly those from Chertsey and Bushey Park, were made by Dr. Braithwaite. All the species have been recorded by later writers from collections made in Britain since Saville-Kent's time, with two exceptions, namely, *Arrhenurus fimbriatus* Koen., and *Acercus torris* Müll.

Drawings.—A great many of the above preparations had been drawn. Some were simply notes in outline of parts for identification and variations of structure, some were finished coloured figures of the adults, larvae, or nymphs. No doubt all the coloured drawings were made from the living mites; one series represented the different methods of egg-attachment, and others were beautifully coloured drawings of sections of internal structure. Very few, however, had been finished enough for publication, not enough attention having been given to the swimming-hairs on the legs, which are such an important feature in some species.

Notes.—There were a large number of notes and short papers on the water-mites, giving localities where found, notes on, and differences in, species, the time of capture, ova deposition, and of escape of larvae; also several attempts at classification. A long paper of about sixty sheets, forming an introduction to the whole subject,* was nearly completed by the author for publication. I will now give a list of the mites in the collection, using the nomenclature of the present time, with the dates when the species was first named, when and where found by Saville-Kent, together with notes on the embryology I have copied from his notes. At the time Saville-Kent was collecting water-mites, the great work he had to depend on for identifying the species was Koch's *Deutschlands Crustaceen: Myriopoden und Arachniden*, 1835–41—a very fine work with beautiful little figures, but a great many of the names are wrong; some were named from nymphs and then named again as adults; some, again, were given specific names on account of differences in colour. All this caused a certain amount of confusion, which has, I hope, been cleared up by now. Piersig, Koenike, Sig Thor, Wolcott, and others who have done all they can to place the nomenclature and classification of the Hydrachnidae on a firm basis, had not begun to make their researches known, hence a number of specific names used by Saville-Kent have been altered to those now in use. It is quite possible that had all the slides been in a good state of preservation I should have found more than the fifty species here given, because Saville-Kent certainly gives more than fifty names. But, basing his work on Koch, he had sometimes given more than one name to the same mite; and, again, in the genus *Eulais* he had named two distinct species as one. However that may be, it is a very good list, and, although rather late, it is only right and fitting that it should be published in honour of a well-known naturalist who, had he lived, would have given us a fine Monograph on our British water-mites.

---

* See p. 261.

List of Species.

The localities are those given by Saville-Kent.

1. **Acercus lapites** Müll., 1781.

Kew Gardens, 1882.

2. **Acercus lutescens** Herm., 1804.

Barnes Common and Wandsworth Common, 1868. There is one slide of a well-developed nymph showing adult forming inside. Ova deposited April 29th; larvae appeared May 11th, 1868.

3. **Acercus ornatus** Koch, 1835.

Pond near Perivale Church, 1869.

4. **Acercus torris** Müll., 1776.

Wandsworth Common, April 25th, 1869. This is the first British record.

5. **Arrhenurus albator** Müll., 1776.

Kew Gardens, 1880. Wandsworth Common, 1881. Acton, 1883. This last year was the year it was first recorded for Britain in *Science Gossip* by Dr. George.

6. **Arrhenurus bifidicodulus** Pier., 1884.

Kew, 1881. Three years before it was named.

7. **Arrhenurus caudatus** de Geer, 1778.

Barnes Common, Wandsworth Common, and Hampstead Heath, 1868.

8. **Arrhenurus crassicaudatus** Kram., 1875.

Kew Gardens, 1868. Saville-Kent gives a pencil drawing of this mite, but it was not named by Kramer until seven years afterwards.

9. **Arrhenurus crassipetiolatus** Koen., 1885.

Two fine male specimens found by Saville-Kent on Wandsworth Common in 1868.

10. **Arrhenurus fimbriatus** Koen., 1885.

Kew Gardens and Wandsworth Common, 1880. This is the first record for Britain, and I have not heard of its being found since. I had to unmount and remount this mite before I was sure of the species—the slide was in such a bad condition. This mite has been found several times on the Continent. I am very pleased to see it in the English fauna, although it has had to wait thirty-one years to be recorded.

11. **Arrhenurus forpicatus** Neum., 1880.

Epping Forest, 1882. In 1881 Dr. George, not knowing this had been recorded and named by Neuman, the previous year, named this mite *A. perforatus*. Even now Piersig, in *Das Tierreich*, p. 113, makes a variety of George's specimen and calls it *A. forpicatus perforatus* George.

12. **Arrhenurus globator** Müll., 1776.

On Barnes Common and several places later (for it is a very common mite), 1868. Ova deposited April 28th, larvae appeared May 15th, 1868.

13. **Arrhenurus integrata** Müll., 1776.

Wandsworth Common, 1869.

14. **Arrhenurus leuckarti** Pier., 1894.

Pond near Perivale Church, 1882.

15. **Arrhenurus maculator,** Müll., 1776.

Epping Forest, 1882.

16. **Arrhenurus mantonensis** George, 1903.

Wandsworth Common, 1867.

17. **Arrhenurus sinuator** Müll., 1776.

Kew Gardens, 1881.

18. **Arrhenurus stecki** Koen., 1894.

Wandsworth Common, 1880.

19. **Arrhenurus truncatellus** Müll., 1776.

Wandsworth Common, 1869.

20. **Brachypoda versicolor** Müll., 1776.

Wandsworth Common, 1868. In addition to the slides, Saville-Kent had a good pencil drawing of the ♂ and a finely coloured one of the ♀.

21. **Diplodontus despiciens** Müll., 1776.

Barnes Common, 1868. Pond between Shepherd's Bush and Hammersmith, and Round Pond, Kensington Gardens, in 1869 on Wandsworth Common. Ova deposited April 26th, larvae appeared May 21st. It is a very common species. There are several slides of this mite, some not fully developed, others of larvae.

22. **Eulais extendens** Müll., 1776.

Wormwood Scrubs, 1868.

23. **Eulais hamata** Koen., 1897.

Bushey Park by Dr. Braithwaite, 1868.

24. **Frontipoda musculus** Müll., 1776.

Epping Forest, 1882. Both red and green variety were in the collection, and a number of good drawings of dorsal, ventral and lateral surfaces.

25. **Hydryphantes dispar** Schaub., 1888.

Barnes and Wandsworth Common, 1868. As well as slides there were good drawings of eggs as deposited and larvae.

26. **Hydryphantes ruber** de Geer, 1778.

Barnes and Wandsworth Common, 1868.

27. **Hydrachna globosa,** de Geer, 1778.

Bushey Park, 1868. Kew Gardens and Round Pond, Kensington Gardens, 1869. Also by Dr. Braithwaite at Chertsey, 1868. Saville Kent in connection with this mite has the following interesting note: "According to Duges this animal deposits its ova in the tissue of water-weeds, first piercing suitable orifices with its mandibles in the water-weeds. Sent me from Chertsey were many dead specimens, which after piercing the tissue had evidently been unable to withdraw their mandibles and consequently perished. A remarkable aberration from the general habits above quoted was instanced by a specimen depositing its ova at the extremity of a long pedicle, and which can only be accounted for on the supposition that the texture of the weeds was of too firm a nature to allow of the animal pursuing its usual course." As well as the above note Saville-Kent gives a slight sketch showing how the eggs appear at the top of the stalks similar to those of the lace-winged fly, *Chrysopa perla*, only the stalk is much shorter in the water-mite.

28. **Hygrobates longipalpis** Herm., 1804.

Kew Dyke, 1882. There is also a good coloured drawing of this mite, showing its beautiful markings on the dorsal surface, also ova and larvae.

29. **Hydrochorentes ungulatus** Koch, 1836.

Kew Dyke and Lake, 1882. There is a good figure showing the ova as deposited on a water-plant.

30. **Limnesia fulgida** Koch, 1835.

Most of the collecting-places in 1868; it is a very common mite. There are some good figures of this mite, and work had been done with the internal and external structures. There was a special slide of sections and some good coloured drawings of same amongst Mr. Saville-Kent's papers, but I could not find any written notes on the internal anatomy, but the coloured drawings were some of the best in the collection. There were also the ova and larvae, and one slide in bad condition, which I take to be that of nymphs.

31. **Limnesia maculata** Müll., 1776.

Epping Forest and Kew Dyke, 1882. Ova deposited May 4th, larvae appeared May 21st.

32. **Limnesia koenikei** Pier., 1894.

Kew Gardens, 1869.

33. **Limnesia undulata** Müll., 1781.

Wandsworth Common, 1869.

34. **Limnochares aquatica** Latr., 1755.

Wandsworth Common, 1869.

35. **Mideopsis orbicularis** Müll., 1776.

Epping Forest, 1882.

36. **Neumania spinipes** Müll., 1776.

Kensington Gardens, 1868.

37. **Neumania vernalis** Müll., 1776.

Shepherd's Bush Common, 1868. Ova deposited April 4th, larvae appeared May 20th.

38. **Piona carnea**, Koch, 1836.

Locality not given, n.d.

39. **Piona conglobata**, Koch, 1836.

Wandsworth and Barnes Common, 1868; a number of males and females of this species, a very common mite.

40. **Piona fuscata** Herm., 1804.

Wandsworth and Barnes Common, 1868. Epping Forest, 1882. Also slides of ova and larvae.

41. **Piona longicornis** Müll., 1766.

Kew, 1882.

42. **Piona longipalpis** Kren., 1884.

No locality given, n.d. But it must have been before Krendowsky named it. It is rather a common mite in Britain, and a very finely coloured species.

43. **Piona nodata** Müll., 1776.

Wandsworth Common, 1869. A coloured drawing of this mite and a slide of partly developed ova.

44. **Piona obturbans** Pier., 1896.

Wandsworth Common, 1868.

45. **Piona rotunda** Kram., 1879.

Hampstead, n.d.

46. **Piona rotundoides** Thor., 1898.

Wandsworth Common, 1869.

47. **Piona rufa**, Koch, 1836.

Wandsworth Common, n.d.

48. **Sperchon** sp. incert.

Barnes Common, species not made out; n.d.

49. **Unionicula crassipes** Müll., 1776.

Kew Gardens and Wandsworth Common, 1868-9.

50. **Unionicula ypsilophora** Bonz., 1783.

Found in the gills of *Anodon cygnea*, also eggs and larvae in mantle of same, from Barnes Common, 1880.

CONTRIBUTIONS TO A KNOWLEDGE OF THE HYDRACHNIDAE.*

By the late W. Saville-Kent, F.Z.S., F.L.S.

So long ago as the year 1860 my attention was attracted to that comparatively little-studied group of the Arachnida known as the Hydrachnidae or Water-mites. In the summer of that and the following year I collected and examined upwards of fifty varieties, in many cases worked out their life histories,† and had already formulated what appeared to me to be a more natural and convenient system of classification for the same than had hitherto obtained. The pressing claims upon my notice from that date forward of other biological subjects obliged me for a while to forego my study of the group, and it is only within the last few months that the opportunity has been afforded me of renewing and extending these earlier experiences. Fortunately the extensive series of microscopical preparations made by me of the majority of species originally collected has been but little impaired by the lapse of time, thirteen or fourteen years, that has intervened since the date of their capture and preservation; and this preserved series, in which not

---

* The Club is much indebted to Mr. S. Hirst, of the British Museum (Natural History). for his kindness in permitting the publication for the first time of his late uncle's contribution to the study of the Hydrachnidae. He writes to say that the paper was probably prepared for publication some time during 1883–4. This is the last date that is mentioned in the rough notes on Hydrachnids. It was in the latter year that Mr. Saville-Kent left England for a long residence in Tasmania and Australia. The folio volume *The Great Barrier Reef of Australia*, published in 1893, embodies the results of his long stay in Australia. [Ed.]

† The life-histories of water-mites are very little known. What Mr. Saville-Kent did was to succeed in breeding the larvae from the adults—a very valuable addition to our knowledge of water-mites; but the parasitic stage of the larvae is more important still, and of that we know very little and without such knowledge we cannot say we know their life-history. [C.D.S.]

only the shapes but for the most part the original brilliant tints of the little animals are perfectly retained, has been of the utmost service in the compilation of this memoir. Before proceeding to technicalities it is desirable to mention that all of the examples upon which these observations are based were collected by me in the neighbourhood of London, and number approximately, with additions made during the past autumn, 1882, upwards of eighty species.

General Morphology

As members of the class Arachnida the Hydrachnidae or Water-mites, as their name implies, constitute a subdivision of the typical mites or ACARINA, specially adapted by the garniture of their locomotive appendages for leading not only an aquatic but an essentially natatory existence. Such garniture takes the form of long slender hairs or setae, developed for the most part in bundles upon the internodes of the ambulatory limbs, and with the aid of which the little creatures propel themselves through the water with remarkable activity. But for the possession of these slender swimming-setae the Hydrachnidae correspond essentially in all broad structural details with the ordinary mites or Acarina, and types are not wanting that serve to indicate the close connection that subsists between these respective groups. The genus *Eulais* of Duges,* in which the posterior pair of limbs is entirely devoid of swimming-setae and takes no part in natation, may be cited among the swimming forms belonging to the Hydrachnidae, while the aquatic but altogether non-natatory genera *Atractides* and *Thyas* of C. L. Koch assist to bridge the two groups from the opposite side. As a character, albeit of a negative order, that serves to distinguish the Hydrachnidae from the more ordinary terrestrial Acaridae it is further found that in no form as at present known is the body subdivided by transverse constrictions into distinct regions or somites as obtains in certain genera such as *Sciurus*, *Eupodes* and *Tyroglyphus*, the whole mass corresponding with the head

---

* The reference for the genus *Eulais* or *Eylais* is Latreille 1796, not Duges 1834. At the time of Saville-Kent's writing only one species was known; we now know about seventy. [C.D.S.]

and thorax or cephalothorax of the higher Arachnida being indistinguishably fused together. The nearest approach to a deviation from this simple type of structure is found in the males of many species of the genus *Arrhenurus*, the posterior extremity of the body in many of these forms being greatly prolonged and not infrequently separated by a more or less incisive constriction from the anterior region. Even in these more exceptional forms there is, however, no distinct line of demarcation or segmentation.

Proceeding to a brief enumeration of the morphological characters of the Hydrachnidae—such being common also to the majority of the Acaridae, or indeed of the entire class Arachnida—it is found that they possess but six pairs of jointed appendages, the two anterior of these, the mandibles and palpi, pertaining to the oral and the four succeeding pairs to the ambulatory or locomotive systems. In addition to these we have the eyes and a pair of antenniform setae developed in advance of the mouth, and behind the locomotive limbs what seem very like the modified basal joints or epimera of the appendages belonging to a ninth body segment, the entire series following each other in the subjoined consecutive order:

1\. Eyes.
? 2. Antennary bristles.
3\. Mandibles.
4\. Maxillary palpi.
5\. 1st
6\. 2nd } Epimera and attached pairs of locomotive limbs.
7\. 3rd
8\. 4th
? 9. Frontal plates or epimera.

As will be observed, the figures indicative of the suggested homologues of the second and ninth pair of appendages in the foregoing scheme are affixed only tentatively. It has long since been generally conceded that the Arachnida as a class are deficient in one of the two pairs of antennary elements possessed by such typical arthropoda as the Crustacea, the pair that is retained indeed not existing under the form of ordinary antennae, but being metamorphosed in such a manner as to constitute the so-called chelicerae or mandibular elements of the ordinary spiders.

The question has naturally arisen from this interpretation as to what has become of the missing pair of antennae, and although at a first glance no satisfactory answer to this inquiry would appear to be forthcoming from the higher Arachnida, some evidence of importance is apparently to be derived from a study of the small group of the Hydrachnida. In a considerable number of these, as for example the genera *Limnesia*, *Hydrachna*, *Eulais* and *Diplodontus*, two more or less remotely separated pairs of simple eyes are developed; while in a second series, including such genera as *Nesaea*,* *Piona*, *Marica* and *Arrhenurus*, but a single pair of visual organs are distinctly recognisable. According to the recent observations of C. J. Neuman † and H. Lebert, ‡ two pairs of eyes represent the normal number possessed by all the members of the group, but the two are so close together that the pigment masses coalesce with one another and thus present superficially the aspect of a single pair only, their compound character, however, being rendered evident by the presence of a double cornea. Without being in a position precisely to endorse this interpretation—the presence of a second corneal element being indeed undemonstrable in many species examined—I have succeeded in tracing the connection of the two eyes on either side, as developed in *Limnesia histrionica* with a single nerve-cord that simply branches towards its distal end, giving off a twig to each ocellus. This fact tends to show that even when developed distinctly in duplicate these visual elements must be regarded as the homologues only of a simple optic organ, or may indeed be appropriately correlated with an elementary condition of the compound eyes of many insects and crustacea, assuming each eye-like structure in the Water-mite to be the equivalent of

---

* For the generic and specific names as now understood we must substitute the following, an alteration which will answer all through this paper: For *Nesaea* use *Piona*; for *Piona* use *Acercus*; for *Marica* use *Frontipoda*; for *Atax* use *Unionicula*; for *Pseudoatax* use *Neumania*; for *Bradybates* use *Thyas*. For *Limnesia histrionica* use *L. fulgida*; for *Diplodontus filipes* use *D. despiciens*; for *Mideopsis depressa* use *M. arbicularis*. *Anurania* as a generic name is not now used, as it was only a nymph stage in an *Arrhenurus*. [C.D.S.]

† "Sveriges Hydrachnider," *Kongl. Sv. Vet. Akad. Handl.* Bd. 17, 1880.

‡ "Hydrachnides du Lac Leman," *Bull. Soc. Vaud.*, t. xvi., 1879.

a single corneal facet with its subjacent pigment mass of such arthropoda.*

It is consequently not the supplementary optic organ that it is here proposed to identify with the missing antennary element of the Arachnid type. There in fact very generally lies between these and what are usually accepted as the succeeding pair of appendages or mandibles of the Hydrachnidae a pair of isolated bristle-like hairs of such relative size and position as to present in many instances the aspect of minute antennae; these hairs are associated usually with an apparently glandular enlargement, and moreover, what is of yet more importance, are connected by distinct filaments with the cerebral nerve-mass. This setiform structure apparently coincides in function, as it does in position, with the first pair of antennae, hitherto supposed to be wanting in this group. It doubtless functions similarly as a tactile organ, and with reference more especially to its independent nerve-cord may be accepted as the homologue of the more usual many-jointed primary antenna of typical crustacea or with the single one of an insect.† It may be observed that two or even three contiguous hairs not infrequently take the place of the more ordinary single antennary bristle, while in none of the sixty or seventy species so far examined has this apparent antennary homologue, though in some cases very inconspicuously developed, been found to be entirely wanting. Glandular hairs analogous to these just referred to and having probably a tactile function are in many forms found distributed at even distances round the periphery of the body, though more particularly towards the posterior region, where possibly they also represent the rudiments of undeveloped appendages.

In addition to the eyes and tactile bristles no other sensory

---

* The correlation here supplied is yet more forcibly illustrated in the case of the typical spiders, which possess for the most part as many as six or eight optic elements, supplied, there is reason to believe, from a single pair of nerve-cords.

† Since arriving at this interpretation I find that the resemblance and probable homology of this bristle-like hair of certain Hydrachnidae with an antennary organ was first noticed by Duges (*Mémoire sur les Acarines* 1834), who, moreover, cites the existence of a corresponding antenna-like bristle in the genus *Galeodes*, but does not appear, however, to have substantiated the homology by tracing out the nerve-connections.

organs are generally recognisable in the Hydrachnidae. In one species of *Arrhenurus* I have nevertheless succeeded in discovering a structure which bears a most remarkable resemblance to an auditory capsule, with enclosed otoliths imbedded within the second joint, from the base of the first pair of ambulatory limbs. Up to the present time, and notwithstanding the well-known circumstance that many of the higher Arachnida possess the sense of hearing in a marked degree, the precise location, or indeed the character, of the auditory organs does not appear, so far as I can gather, to have been recorded in connection with any representative of this class of the Arthropoda. The seemingly anomalous position of these auditory structures, if such they be, in *Arrhenurus* is reconcilable with the circumstance that while in the majority of the podopthalmous crustacea homologous organs are imbedded within the basal joints of the antennules, in other members of the same group, *e.g. Mysis*, they may be found similarly immured within the endopodites of the last abdominal somite. In all the Hydrachnidae, with but one or two exceptions leading a free-swimming existence, it is found that their oral armature conforms very closely with that of the typical Arachnida, and especially with that of the true spiders or Araneida, and is neither metamorphosed nor disguised by atrophy, as so generally obtains among the more numerically abundant parasitic Acari. The more anterior or mandibular element in this oral system consists of a thicker basal joint surmounted by a curved ungulate or ensiform very sharply pointed terminal prolongation, the two combined composing an appendage that bears a considerable resemblance to the homologous organs or so-called chelicerae of the typical spiders. The function that they perform is likewise substantially identical, it being with these weapons that the captured prey, consisting for the most part of living Entomostraca, or minute water-insects, is perforated and held in close proximity to the suctorial mouth. As is well known, in the case of the true spiders a poison-gland communicating by a fine duct opens upon the apical extremity of the chelicerae. Although no such lethal structure has so far been recorded in connection with the Hydrachnidae, I have recently succeeded in detecting what I believe to be an organ of corresponding value in several species, notably in *Limnesia histrionica* and also in various terrestrial Acari. The very circumstance of the irritating effect of the bites of certain Acari, eminently that of the so-called Harvest-bug (*Leptus* or *Tetrarychus autumnalis*), would certainly justify an anticipation of the existence of such a structure. According to the more recent researches of C. J. Neuman,* the mandibles in certain Hydrachnidae, such as *Lebertia*, *Midea* and *Anurania*, is supplemented by a second more minute opposing stylet, which consequently imparts to the appendage the aspect of a true chela.

The second pair of pointed appendages or palpi of the Hydrachnidae, stationed immediately in advance of the four pairs of locomotive limbs and homologous with maxillary palps or pedipalpi of the typical spiders and with the great claws or chelae of the scorpions, vary somewhat in structure among the different members of the group, such divergences as exist yielding convenient correlative characters for generic diagnosis. With the majority of forms these palpi, which consist of five joints, are simply oval-shaped or denticulate at their distal extremity, while in a few others, such as the genera *Arrhenurus* and *Hydryphantes* the penultimate joint of each palpus is so prolonged at one of its distal angles as to constitute, in conjunction with the short fifth or terminal joint, a prehensile claw or chela like that of a scorpion or lobster. The bases of the palpi are in all instances united by a movable joint to the anterior or lateral angles of a chitinous lower lip-like structure or labium, which embraces and conceals the mouth and mandibles in a sheath-like fashion and is not infrequently produced anteriorly in such a manner as to constitute a distinct proboscis or rostrum. The composition of this labium through the coalescence of two lateral pieces is evident in many species, and there would therefore appear to be justifiable grounds for anticipating that these labial elements are the homologues of the extended basal plates or epimera of the succeeding locomotive appendages.

The locomotive limbs, to the number of four pairs, which follow upon the oral appendages exhibit no marked structural differences, all consisting of six distinct articulations, and the proximal point of each being united to a more or less extensive adnate chitinous induration of the ventral surface of the

---

* *Sveriges Hydrachnider.*

body. These chitinous expansions, the epimera, usually forming two independent symmetrical lateral series, but occasionally continuing with one another in the median line, while morphologically homologous with the motile basal elements of the seven-jointed ambulatory limbs of the true spiders, exhibit a more strict physiological correspondence with the expanded adnate bases of attachment or sternal elements as developed in the scorpions. The comparative proportions and the positions relative to each other occupied by the epimera of the Hydrachnidae are found to afford valuable correlative data for the construction of their generic and specific diagnoses. In most instances the six-jointed locomotive appendages dependent from the epimera terminate similarly in a double or yet more complex claw, accompanied frequently by a groove-like excavation of the terminal joint of the limb from which it extends, and into which groove it may be reflexed at will as into a sheath. In some forms the claw-like structure is trifid or even quadrifid, while, on the other hand, in certain genera, *e.g.* *Limnesia* Koch, the hindermost limb has a perfectly simple non-ungulate termination. It is worthy of notice that in not a few genera, such as *Nesaea*, *Arrhenurus* and *Hydrochorentes*, the antepenultimate joint of the third or fourth locomotive limb in the males only is so modified as to constitute an efficient crook or clasper, for the better retention of the female during copulation. A similar structural and functional modification of the hinder limbs in the male individuals is found to obtain among many of the terrestrial Acari, notably in the parasitic genus *Dermaleichus*, but does not seem to occur among any of the higher Arachnida.

While the fourth pair of legs in the Hydrachnidae represents, as in all other Arachnida, the most posteriorly developed jointed appendages, there yet exist what it is here anticipated may be correctly interpreted as representing the sternal elements or epimera of the succeeding body somite. On the ventral surface of these Water-mites, in fact, immediately behind or at some little distance from the epimera of the fourth pair of locomotive limbs and between these latter and the anal aperture, will be generally found two adnate bilaterally symmetrical chitinous plates, of various forms and ornamentations in different species, which enclose between them the genital fissure. Although such structures, which may be conveniently distinguished by the title of the genital plates, are not met with among the higher Arachnida or true spiders, a closely analogous element occurs in those singular organs, the so-called crab-like structures or "pectines," developed one on either side immediately to the rear of the genital aperture in the scorpions. The precise import of these "pectines" in the scorpion does not, so far, appear to have been determined, though it is very likely they are subservient in some way to the phenomena of copulation. These apparently closely analogous structures, the genital plates of the Hydrachnidae, are unquestionably associated with a coincident function, and are indeed in many cases provided with acetabular surfaces that assist in the close union of the genital areas during the pairing of the sexes. As will be presently shown, the contour and pattern of these genital plates, or, as here suggested, basal elements of the ninth pair of somital appendages, afford valuable aid both in forming the generic diagnoses of the group and in discriminating between closely allied species.

ALIMENTARY SYSTEM.

The alimentary tract in the Hydrachnidae, as with the higher members of the same class, is subdivisible into three distinct regions of a fore-gut, mid-gut and hind-gut. The fore-gut or pharynx and oesophagus, leading from the mouth to the stomach, is straight and of but short length. The two glands apparently partaking of the same nature as the poison glands of the true spiders, and doubtless the modified homologues of ordinary salivary glands, previously referred to, may be regarded as appendages of the anterior or fore-gut. The mid-gut or stomach, as in the typical spiders and other Arachnida, is conspicuous for its development of caecal diverticula. In a large number of forms these caeca are found to follow roughly, as viewed sternally, a quincuncial plan of disposition. The single median element in such quincunx is stationed in advance of the central point, while the two postero-lateral caeca are of more considerable length than those pertaining to the central or antero-lateral systems. In an almost equally considerable series the antero- and postero-lateral caeca coalesce with one another on either side in such a manner that the caecal system is represented by one antero-median and two prolonged lateral elements, and it is indeed found that this formula for the most part obtains where superficially the disposition is quincuncial, the apparent subdivision into two independent caeca being caused by each lateral caecum, as viewed from above, dipping down out of sight into the body cavity and again reappearing on the surface. There are nevertheless many types, such as *Diplodontus filipes* Dug., in which the number of caecal prolongations is greatly augmented and exhibit a stellate plan of disposition more nearly conforming with that of the true spiders. The colour of the caecal diverticula varies in different species from tawny yellow to deep chocolate-brown, such tint being due to the cellular elements of a glandular nature which closely invest the caecal walls throughout their length. There is every reason to believe that these coloured glandular caeca fulfil a digestive purpose, and indeed a similar morphological and histological composition characterises the digestive or formerly so-called hepatic organ both in many arthropoda and other higher invertebrates. In the same manner that the hepatic element invests the wall of the stomach or mid-gut, it is found that the excretory structure correlated, so far as it is possible to determine, with a renal organ, is applied to that of the hind-gut or third division of the alimentary tract. With the hind-gut it describes, in the first place, a straight course along the anal line from the subcentral stomach to the posteriorly and ventrally located anal aperture. At the commencement of its course it likewise, almost invariably, gives off two arm-like lateral diverticula, which, combined with the straight median element, confer upon the hind-gut with its renal investment, as seen from above, a characteristic Y- or T-shaped contour. The granular substance that enters chiefly into the composition of the excretory organ varies from chalky white through yellow and orange to deep vermilion, and being in many instances of considerable breadth, contributes extensively to their gay colouration. In numerous species the simple Y- or T-shaped contour of the excretory organ is rendered more complex by additional diverticula, which may be developed from the extremities of the lateral arms, from the centre of the main gut, or from its anal termination. Though subject to slight variation, even among individuals of the same species, the broad plan and disposition of this coloured excretory structure in the main holds good for each species, and hence furnishes a valuable accessory for the purposes of specific diagnosis.

Circulatory and Respiratory Systems

No heart or other vascular apparatus has so far been discovered in the Hydrachnidae or ACARINA generally, nor to compensate for such absence is the vital fluid propelled, as in many lower arthropods, by the muscular contractions of the walls of the perivisceral cavity. In place of this, as first pointed out by Claparède,* the amoebiform blood corpuscles are endowed with extraordinary vitality and creep freely about within the liquid plasma contained within the lacunae or interspaces of the limbs and body cavity.

Concerning the respiratory system of the Hydrachnidae, it has fallen to my lot to place on record an account of certain structural and physiological details that have seemingly escaped the notice of all previous investigators. Since the time of Duges, the possession by the members of this group of an extensively developed tracheal system has been generally recognised, different authorities, however, being at variance with respect to the manner in which these tracheae are brought into relation with the external surface of the body. By many of these it was supposed that either all or a certain number of the minute circular apertures or so-called stigmata, distributed symmetrically in varying positions upon the dorsal and ventral surfaces of the body, were the direct openings of these tracheae as obtains among the ticks and other terrestrial Acari and higher Arachnida. As, however, first demonstrated by Claparède† in the case of *Atax crassipes* and *A. ypsilophorus*, these stigmata are the excretory orifices of special integumentary glands, and an analogous function and import, so far as is at present known, must be connected with these structures in all other Hydrachnidae.

---

* "Studien an Acariden," *Zeitsch. Wiss. Zool.*, Bd. xviii., Hft. iv., 1868.

† *Ibid.*, p. 479.

Claparède in thus demonstrating the true nature of these so-called tracheal stigmata recorded of *Atax bonzi* the existence of certain circular epidermic areas which readily coloured under the action of osmic acid, and which he anticipated might be connected with a respiratory function. Of the allied form *Atax ypsilophorus* he further reported detecting in rare instances and in young examples only a system of tubular channels containing a clear fluid, which, having their origin in the neighbourhood of the rostrum, were developed backwards into various branches along the dorsal surface and opened apparently with infundibulate expansions upon the perivisceral cavity. The respiratory apparatus of the adult animals as represented by distinct air-passages or tracheae appears to have altogether escaped Claparède's observation, possibly from his investigations having been conducted in connection with alcoholic specimens, under which conditions the tracheal tracts become more or less completely obliterated.

Dr. P. Kramer, as the result of a much more recent examination of this group,* has declared that the tracheal passages of the Hydrachnidae, coalescing so as to form two single tubular passages in the neighbourhood of the head, finally open externally, as in the Tromfidiidae, by two distinct though closely approximating apertures upon the summit of the rostrum. In this manner they are held to differ more especially from the Oribatidae, Gamasidae and Ixodidae, in which the tracheal stigmata open respectively upon the thorax or a yet more posterior region of the ventral surface. Dr. S. Haller † has still more recently endorsed Kramer's declaration with respect to the tracheal openings of the Hydrachnidae, but, as I now propose to demonstrate, the interpretation arrived at by these two authorities is incorrect to the extent that they have altogether overlooked a not easily recognised but at the same time very important structural point. The opening of the tracheal tubuli directly upon the external surface after the manner of ordinary terrestrial air-breathing arthropods, as maintained by Kramer and Haller, has, I must confess, appeared to me

---

* "Zur Naturgeschichte der Hydrachniden" and "Grundzüge zur Systematik der Milben," Troschel's *Archiv für Naturgesch.* 1875, 1877.

† "Die Hydrachniden der Schweiz," *Mitth. Bern. naturforschende Gesellschaft*, 1882.

altogether inconsistent with the essentially subaqueous habits of the Hydrachnidae * and I have therefore been hitherto more inclined to adopt the view that they absorbed air into their trachea through the general surface of their integument, the respiratory system being thus, as originally suggested by Duges, most nearly comparable with the closed tracheal or tracheo-ventral system of the Insecta. I was scarcely prepared, however, to find how close an analogy subsists between the two groups with respect to their air system as has now come to light. In the first instance, with the view to arrive at a correct estimate of the origin and distribution of the tracheal tubuli, sections were made of fresh examples of various species, but more particularly of *Limnesia histrionica*, some with the freezing microtome and others with simply a fine pair of scissors. Their bodies being laid open, it was found that the tracheae converging from all regions formed a thick plexus upon the wall of the stomach and oesophageal tract; and no more extensive system of tubuli apparently passing off thence to the anterior region than was distributed to other portions of the body, such as the locomotive limbs, it was anticipated as not improbable that the thick tracheal plexus coating the stomach and oesophagus extracted air from the water taken into the body through the mouth and held in suspension by these viscera. It was only by carefully detaching and examining separately the rostra, bearing the mandibular and palpiform appendages, from a considerable series of examples that the true condition of affairs was revealed. The two tracheal tracts described by Kramer as leading to the summit of the rostrum were now distinctly shown; but in place of terminating there as stigmatal openings as described by him and Dr. Haller, it was found that from each of these points was developed an exceedingly delicate film-like saccular expansion of the surface of the integument into which the tracheal tubuli ascended and formed a convoluted plexus, in a manner altogether identical with what obtains in the leaf-like tracheal-gills of the larvae of the Ephemeridae and other aquatic insects. The two structures are in point of fact precisely homologous, and it is an interesting circumstance thus to

---

* Many species are now known to be limited in their distribution to the deeper waters of the Swiss lakes, while specimens kept in aquaria live for months without coming to the surface of the water.

find, not only a modification of the respiratory apparatus hitherto not known to obtain in any representatives of the Arachnida, but a condition which as developed here in the adult state corresponds with what is met with only during the larval condition in the class Insecta. These cephalic tracheo-branchiae as developed in *Limnesia histrionica* have been identified in *Hydrachna globula*, where the membranous tracheal sacculi project in a more horizontal direction from the roof of the rostrum, and also in *Diplodontus filipes*, *Atax bonzi*, *Atax crassipes*, and indeed in all the species specially examined for these structures. Examined without dissection either living or dead it has been found impossible to recognise the existence of these tracheal-gills, they being under such circumstances concealed and at the same time effectually protected by the overhanging convexity of the anterior region of the animal's body; while in order to display it in connection with its basis of attachment, the greatest care is requisite to avoid lacerating in the operation of severing the rostrum from the body the delicate membrane of which it is composed.

According to Kramer's representation, that portion of the tracheal system which ascends vertically to the roof of the rostrum consists—at least in the unnamed species of *Nesaea* which he figures—of two corresponding relatively large tubuli that exhibit, as in the trachea of the Insecta, a distinct spiral fibrillation, out of which at their lower or proximal end directly decussate a number of the simple unstriated tubuli as distributed throughout the body. In no instance up to the present time have I been able to corroborate Kramer in this particular, in all examples personally examined the tracheal tubuli produced from the sides of the oesophagus to the summit of the rostrum, though so closely approximated as seemingly at first sight to form a single tube, remaining distinctly separate throughout their course and forming independent terminations within the gill-like membranous expansion just described. No spiral fibrillation could in any case be detected, and in this circumstance the tracheae agree with what obtains in all known representatives of the Arachnida class. The tracheal tubuli of the Hydrachnidae, it is worthy of note, with regard to the absence of a spiral filament, their generally unbranched character and paniculate disposition, accord in a remarkable manner with the same structures as developed in that singular low-type arthropod *Peripatus* figured and described by Prof. H. N. Moseley.

DERMAL GLANDS.

The dermal glandular system throughout the Hydrachnidae attains to a very considerable degree of development, though in no species hitherto described does it appear to exhibit so marked a degree of differentiation as has here to be recorded of *Limnesia histrionica*. By so early an investigator as C. L. Koch,* the annular orifices of the separate gland systems upon the cuticular surface were distinctly recognised, though, as already stated, misinterpreted as stigmatal apertures. Since Claparède's demonstration of their true nature in the cases of *Atax crassipes* and *A. ypsilophorus* a like structural composition has been identified by Kramer and Haller to obtain in a variety of forms, though in none of these is it shown that the glands opening at the stigmata-like apertures exhibit anything beyond a simple follicular structure, though they may unite in a common excretory duct for a short distance before arriving at the surface of the integument. It is noteworthy, however, that Haller, so far as the apertures themselves are concerned, has observed and delineated a species of *Hygrobates* in which these are differentiated upon as many as two or three distinct plans. In the majority of instances these apertures are closed by membranous valves and have associated in their immediate vicinity a single hair or seta, while the subjacent glands take the form of simple pyriform follicles. In a second less abundant series the apertures are simply circular, closed apparently by a sphincter muscle and without an attendant seta. Haller prefers to identify these with the circular areas recorded by Claparède of *Atax crassipes* as being readily affected by osmic acid, and further hazards the opinion that they may represent a modified water-vascular system, anomalous though such a structure would be in connection with an arthropodous type. Thirdly, he has distinguished the existence, though more rarely, of paired oval apertures upon the dorsal region, which, like those of the second order, are un-

---

* *Ubersicht der Arachnidensystems*, 1842.

accompanied by a seta. The significance of these Haller was unable to determine.

Reverting now to *Limnesia histrionica* as personally examined, it has been found easy to recognise two orders of stigmata-like apertures upon the surface of the cuticle—those of the one series being accompanied by, and those of the other being devoid of, a setose appendage. In accordance with Haller's observations it has likewise been found that the structures associated with these respective apertures differ to a marked extent from each other, though in a manner distinct from what that authority has described of *Hygrobates.* In connection with the two pairs of apertures situated towards the anterior region of the dorsal surface are developed the rosette-like clusters of simple pyriform glands first described by Claparède in *Atax crassipes* and as yet alone recognised in these types. Those belonging to the remaining order, and numbering upon the dorsal surface as many as seven pairs, are distinguished by the extraordinary length and tenuity of the glandular elements, which consist of a complex network of tubules or cannuli, developed upon a dichotomous plan from the larger common tubular passage that opens upon the dermal apertures. As fully developed in adult examples these glandular tubules of the collecting system so approach one another at the peripheral edges as to form an almost continuous rete beneath the cuticular surface. This rete, however, does not come in immediate contact with the cuticle, there being interposed between the two that finer network of tracheal threads previously referred to as forming a delicate abundantly intercrossing plexus upon the dorsal surface. Prior to arriving at a correct apprehension of the tracheóbranchial system of *Limnesia* and other Hydrachnidae it was anticipated that the tubular glandular retia with their external openings might absorb fluid from the exterior and thus form a sort of water-bed from which the superjacent tracheal tubuli could separate out the air requisite for respiratory purposes, and which could not be similarly derived through the relatively dense substance of the cuticle. The discovery, however, of a specialised tracheal-gill rendered nugatory such earlier interpretation and contributed towards their identification as specially modified mucous glands. In conformation they are found in part, as in the case of the trachea, to correspond more closely with the homologous structures as developed in *Peripatus* than with those of any other arthropod. In certain histological details they nevertheless differ conspicuously from the glandular structures, mucous or otherwise, hitherto recorded. Notwithstanding, in fact, that these structures have been carefully examined under the highest magnifying powers both fresh and after treatment with osmic acid and many other reagents, it has been found impossible to detect the presence of any cellular elements. The walls of the tubuli themselves, while rapidly absorbing coloured media, exhibit no differentiation whatever; a circumstance that would appear to warrant their interpretation as chitinous structures which, dipping down into the cellular elements of the somatic cavity, derive thence, by endosmosis, their characteristic mucilaginous existence. It is worthy of note that in connection with certain media, such as pure glycerine, the contents of these tubuli become highly vacuolate, while their outer walls become variously dilated and distorted, or may even coalesce with those of neighbouring tubuli and apparently thus form one homogeneous mass.

Reproductory System.

The sexes of the Hydrachnidae, as in the majority of the Acarina, are distinct, the ova or seminal elements, as the case may be, being developed in reproductive sacculi that open upon the usually ventrally and mesially located genital aperture. According to Claparède, the ripening ova become detached and lie loosely within the somatic cavity. This interpretation has, however, been called in question by Kramer, and is opposed to the results obtained by the author of this paper by means of sections made in connection with a variety of species, a like relationship of these parts being also found to obtain in association with the testes and their products. Reference has already been made to the specially modified chitinous indurations of the cuticular surface that bound each side or are developed within the neighbourhood of the genital aperture. These structures, which vary to an almost indefinite extent, are found not only to afford reliable data for specific discrimination, but both alone or in correlation with other structural details are found to yield a most readily comprehended clue to the generic groups into which the Hydrachnidae, by the common consent of the students of this order, are naturally divided. By O. F. Müller, the earliest biographer of this group, all its members were included in the single genus *Hydrachna*, and the diagnoses of the various species based merely on the varying colours and broadly perceptible divisions of external contour. C. L. Koch, who up to the present time has figured and described the greatest number of known species, while citing the distinctions of the palpi and mandibles, entirely overlooked the modifications of the genital plates and laid the greatest stress upon the number and relative positions in the dorsal region of the apertures of the mucous or dermal glands, his so-called stigmatal openings. As a matter of practical experience it is found, however, that the characters thus suggested by Koch are amongst the most obscure and difficult to recognise, and, moreover, in but few instances conform to the formulae he has submitted. Dujardin, in his account of the four or five species only examined and described by him, was the first to place on record the distinctive characters afforded by the genital plates, but neither to him nor to the authorities who have succeeded him does it seem to have occurred that the modifications of these structures afforded a sound basis for generic diagnosis, Kramer, Neuman, Haller, Lebert uniting under the same generic headings forms in which the greatest divergence obtains with respect to the character of the genital plates and many other correlative modifications. That the character of these plates afforded the most readily apprehended clue to the generic grouping of the Hydrachnidae was recognised and selected for future use by the author of this paper in connection with the series collected and preserved so far back as the year 1868, and the more extensive knowledge of the group that has been more recently accumulated through the investigations of the above-named authorities have but tended to confirm and permit the extension of this selected standard.

In the modifications of the genital plates of the Hydrachnidae, which, as before stated, we have regarded as the homologues of the basal elements or epimera of a ninth undeveloped limb system, Nature seems indeed to have produced a sort of heraldic code for the special benefit of systematic zoologists that may be likened to the escutcheons and armorial bearings of the human families, and whereby we may deduce the co-existence of all those other correlative, morphological, developmental and aetiologic characters upon which, with the consent of recent biologists, the generic delimitations of the Hydrachnidae may be most logically based. How far this proposed key holds good may be the better determined after an examination of the scheme, with its accompanying illustrations, that has now to be submitted.

CLASSIFICATORY SYSTEM (GENERIC SUBDIVISIONS).

Taking the Hydrachnidae as a family group, and examining the extensive modifications presented by the genital plates, it is easy to recognise that the majority of these are at the outside modelled upon two or three distinct plans only, or indeed that the whole series allow, as might have been anticipated, of the interpretation of being the derivations of some common ancestral type. In the first place, it will be found that in a considerable number of types, including notably such genera as *Limnesia*, *Lebertia*, *Mideopsis*, *Marica*, *Midea* and *Pseudoatax*, the genital plates take a symmetrically ovate form remarkably resembling the ordinary stomata of the leaves of plants, and differ from each other only in the number, form and disposition of their tubercular ornamentations. In a second equally abundant series, comprising such forms as *Nesaea*, *Hydrochorentes*, *Piona*, *Hygrobates* and *Diplodontus*, the dominant contour of the conjoined genital plates is that of a heart with its apex directed forward, the several genera differing only *inter se*, as in the former series, in the number, relative size or form, and disposition of the included tubercles or acetabula. Starting with these two more prominent modifications, it is easy to arrive at any of the apparently anomalous types. In this manner it may be supposed that the prolonged tuberculated genital areas characteristic of the genera *Arrhenurus* and *Anuranea* are but modifications of the tuberculate heart-shaped genital areas of such a form as *Nesaea* or *Diplodontus*; while again, in such genera as *Hydryphantes* and *Bradybates* we have apparently an intermediate condition between the stomata-like and heart-shaped series. The seemingly anomalous form *Pontarachna*, figured in the year 1840 as forming a perfectly symmetrical undivided circular genital area, will, it may be anticipated, on reinvestigation be found to be composed of two closely apposed semicircular tuberculate plates, and be thus shown nearly to approach what obtains in *Pseudoatax*. In but one type out of the whole family group, *i.e.* the genus *Eulais*, do we find that the genital area is in both sexes devoid of tuberculation, and, indeed, genital plates as such are altogether suppressed. This exceptional instance is, however, of the highest interest, since in this genus we get a connecting link between the typical Hydrachnidae and the ordinary ambulatory mites which quite exceptionally possess tuberculated genital areas, as shown by the non-development of swimming-hairs upon the hindermost pair of legs and in the non-participation of these appendages in the natatory function. The males only of the genus *Arrhenurus* are likewise for the most part deficient in genital tuberculations, such circumstance being explicable by the fact that the generative organ in the male of this genus is specially modified and occupies a distinct postero-terminal position. The import of the genital plates or areas of the Hydrachnidae, with their more or less numerically developed tubercles or acetabula, has so far been left unexplained, but they may be interpreted as organs of adhesion, and also probably of touch, through the medium of which an accurate approximation of the genital areas is brought about during the pairing of the sexes, which takes place while the animals are swimming in mid-water.

Genus I.—**Pseudomarica** Neuman.

Body elongate depressed, cuticular surface soft with scattered marginal setae; all four pairs of locomotive limbs decussating from the anterior extremity of the body, their epimera united together so as to form a continuous plastron-like sternal shield; genital plates simple, elliptical, with three elongate ovate tubercles situated close to the inner border of each respective plate, a stiff seta developed from the posterior margin of either plate; palpi simple, subulate; terminal joint of hindermost leg provided distally with one long and two short setae in place of a claw; eyes forming but one distinct pair. Type: *Pseudomarica formosa* Neuman.*

This genus has been instituted by Neuman for the distinction of a form which he thinks may be possibly identical with *Marica oblonga* of C. L. Koch, and which is distinguished from the typical members of such genus by its depressed instead of compressed body, additional characters of distinction being afforded by the scattered setae developed upon the margin of the body and from the fine posterior edges of the genital plates. Other depressed forms awaiting the examination of modern investigators, and that will apparently have to be relegated to the same genus, are the *Marica virescens*, *M. lopida*, *M. strigata*, *M. oblonga*, and *M. confinis* of C. L. Koch. In the writer's opinion, *Pseudomarica* must be regarded as one of the most interesting and important generic forms of the Hydrachnidae, it coinciding more nearly in general structure and configuration with the larval conditions of this family group than any other known type, and in which connection it would seem to occupy the position of a primitive form or archetype. The developmental phenomena, which with respect to neither this nor the succeeding genus have been so far observed, will probably prove of interest. No representative of the genus *Pseudomarica* has, up to the present time, been obtained by the writer in this country.

Genus 2.—**Marica** C. L. Koch.

Body laterally compressed, the cuticular surface indurated, with a rectilinear suture-like ridge developed down the centre of the dorsal border; all four pairs of legs decussating from the anterior extremity of the body, their epimera united so as to form a continuous sternal shield; genital plates elliptical, with a differentiated external border, beset with numerous setae and

---

* *Pseudomarica*, Neuman.—This genus is now known as *Oxus*, Kramer, who first used this name in 1877. Neuman did not introduce *Pseudomarica* until 1880, and the type species *P. formosa* is really Müller's species which he called *Hydrachna strigata*; the proper name is *Oxus strigatus*, Müll. Saville-Kent also mentions in this paragraph besides *M. strigata* two others of Koch's names which are only synonyms of the same mite, *M. oblonga* and *M. confinis*. We have now four species recorded for the Britannic area ; *O. strigatus*, Müll. ; *O. ovalis*, Müll. ; *O. longisetus*, Berlese, and *O. plantaris*, Sig Thor [C.D.S.]

having three elongate tubercles developed in a linear series on the inner margin of each plate; palpi simple subulate; terminal joint of hindermost leg devoid of a claw and having several setae of variable length developed in its place; eyes forming but one distinct pair. Type: *Marica musculus* Müll. sp.*

The abnormally compressed contour of the body in the genus *Marica*, conjoined with the insertion of all four pairs of setose swimming-legs at the extreme anterior end of the body, confers upon its members a remarkable resemblance to certain Cladocerous Crustacea, such as the genus *Daphnia*, this likeness being further supported by the presence of the median suture-like dorsal ridge which separates the indurated cuticular covering into right and left equal halves. The presence of this ridge, together with the compressed form of the body and development upon the external borders of the genital plates of a differentiated granular area, serve to distinguish the members of the present genus from the several forms now relegated to the preceding genus *Pseudomarica*. Out of the seven species formerly referred to this genus by C. L. Koch, but two, *M. musculus* and *M. ovalis*, appear to possess those fundamental structural characters upon which the amended diagnosis of the genus is here framed. To these two a new species, *M. cruenta*, discovered in the country by the writer, is now added. In the *Marica virescens* and *M. lopida* of C. L. Koch, here referred to *Pseudomarica*, the bodies while not compressed are less distinctly depressed than are the four other species with which they are associated, and will probably be found on reinvestigation to possess other points indicative of their transitional position with relation to these allied genera.

Marica cruenta J. K., n. sp.

Body compressed, elongate, elliptical, and about twice as long as broad as seen from above, in profile view suborbicular with a

---

* *Marica*, Koch.—This genus now bears the name of *Frontipoda*, and contains only one species, *Frontipoda musculus*, a species very common in England. The new species named by Saville-Kent, *Marica cruenta*, is really only a variety, as there is no specific difference in the green and red *Frontipoda* except the colour. Both colours are common, and Saville-Kent had both, as I have mentioned in another note. At first sight *Oxus* and *Frontipoda* are much alike, both being long and narrow, but *Oxus* is depressed, while *Frontipoda* is compressed [C.D.S.].

straightened ventral border; general colour of body deep Indian red, with a pale ochreous band produced down the centre of the dorsal region, legs and palpi ochreous yellow with black spines; genital plates elliptical, very prominent, not conspicuously hirsute, surface of cuticle finely areolate.

This species is prominently distinguished from all the forms hitherto referred to the genus *Marica*, either in its broader sense as first established by Koch or, as here delimited, by the red hue of the general area of the body, green, yellow, or brown alone being the equivalent tints of the forms previously described. The contour of this species as seen in profile view is much more orbicular than that of either *M. musculus* or *M. ovalis*, and as compared with the former of the two above-named species—of which we alone have, through Neuman, any minute structural details—it differs in the much less conspicuous development of the marginal fringe of hairs upon the genital plates and correspondingly smaller relative size of those accompanying the gland-apertures developed at intervals along the median dorsal line. Neither has the writer been able to detect in the present species any finely serrated spines at the joints of certain of the legs, as observed by him, but not hitherto recorded, of *Marica musculus*. So far but a single example of this species, taken from a pond on Wandsworth Common in April 1869, has been collected by the writer, and it has not been thought advisable to take this type-specimen to pieces to examine the possibly slightly varying characters of the mandibles and palpi as compared with those of the form last named. The members of the genus *Marica* in accordance with the writer's experience must be reckoned among the most sparsely represented generic groups so far as this country is concerned, since during many seasons devoted to the collection of these Water-mites but a single example of *Marica musculus* only has been obtained in addition to the solitary specimen of the new form here introduced.

With reference to this specimen of *M. musculus* several structural points were observed by the writer that appear to have escaped the attention of Neuman when making his drawings and diagnosis of the species. More especially no reference is made to the delicate areolation of the indurated cuticular surface, which in this respect coincides closely, except for its finer character, with that of the *Arrhenuri*. The pattern of this areolation in *M. musculus* corresponds essentially with that of *M. cruenta*. Neuman neither in his diagnosis nor figures indicates the existence of any hairs or setose appendages attached to the body of *M. musculus* beyond a single pair of setae projecting from the postero-ventral region. As a matter of fact a similar pair is found in connection with each of the ten or more couples of stigmata-like gland-apertures developed at subequal distances throughout the entire length of the median, dorsal and ventral regions. The prominent genital plates again, represented in Neuman's figures as entirely bare, are abundantly clothed with hairs, a prominent uniserial fringe of larger ones defining the periphery of the ventral border and numerous smaller ones being developed upon its labial surfaces.

A point of some interest has been observed in connection with the structure of the posterior legs of *Marica musculus*. A recognised diagnostic feature in this genus consists of the fact that the distal joint of the appendage terminates, not in symmetrical claws as with the three antecedent limbs, but in an attenuate style suggesting an affinity with *Limnesia*, and two or more shorter setae. Neuman in his figures of the species represents two longer and one shorter setae in occupation of this position. In the single example examined by the writer, while one long style and two shorter setae form the termination to the right posterior leg, the distal joint of the corresponding left leg is provided with a double claw similar in all respects to those which arm the terminations of the three preceding pairs of appendages. Whether this asymmetrical armature of the posterior limbs in the species is of common occurrence can be determined only by the examination of a large number of examples. Unfortunately a mutilation of the left posterior limb of the single specimen of *M. cruenta* prevents the determination of a like abnormality in that species.

Genus 3.—**Lebertia** Neuman.

Body symmetrically ovate, cuticle smooth and soft with a few short hairs; epimera of all four pairs of legs coalescing with each but the area of the right and left pairs delimited by a median rectilinear suture; the two posterior pairs of legs furnished with swimming-setae; palpi simple, subulate, profusely setose; genital plates symmetrically elliptical, each plate bearing three serially and medianly disposed ovate tubercles; eyes constituting but one distinct pair. Type: *L. insignis* Neuman.

But a single species of this form, the *Lebertia insignis* of Neuman, has been so far discovered, and this cannot yet be recorded as a denizen of this country. While the coalesced condition of the epimera and pattern of the genital plates predicate its close affinity with the two preceding genera, the distinctly developed median suture separating the epimera of the right and left divisions of the body would seem to indicate a structural development towards those forms in which these basal elements of the ambulatory appendages are completely isolated.

Genus 4.—**Mideopsis** Neuman.

Body suborbicular, depressed: cuticle indurated, granular, with an impressed subcircular dorsal area, a fascicle of two or three antennary setae developed on each side of the anterior border and other isolated setae upon the peripheral border and dorsal surface; epimera forming two distinct groups through the coalescence of the right- and left-hand elements respectively; swimming-hairs developed upon the two posterior pairs of legs, all four pairs terminating in a double claw; palpi subulate, extensively setose, the fourth joint with an inferiorly developed tooth-like projection; genital plates evenly ovate, with three internal lineally disposed tubercles on either side and a broad granulate non-tuberculate border; eyes forming but a single distinct pair; ova and larvae undescribed. Type: *Mideopsis depressa* Neuman.

A single example of the above-named type-form of this genus was obtained by the writer from the lake in Kew Gardens Park in 1881. Contrary to Neuman's intimation in his diagnosis that the species possessed no dorsal stigmata, the writer has recognised distinctly in the example captured at Kew and preserved in glycerine the presence of four pairs of such glandular orifices, each accompanied by a tactile seta, within the area circumscribed by the dorsal impression, and, in addition to these, seven pairs of marginal setae, in place of the four only as described by the above-named authority. The granular character of the cuticle in conjunction with the impressed dorsal area is suggestive of an affinity with *Arrhenurus*, while the character of the palpi and genital plates more nearly approaches *Limnesia*.

Genus 5.—**Limnesia** Koch.

Body symmetrically ovate, inflated: cuticle soft and pliant; short isolated glandular setae scattered sparsely over the cuticular surface, one pair of setae upon the anterior border of the body of larger size and presenting an antenniform aspect; epimera forming four distinct groups, the two anterior and the two posterior pairs on either side being respectively adnate, the epimera of the fourth pair of legs constituting a triangle, the base resting upon the antecedent epimera and its apex giving attachment to its decussating limb; the two posterior legs bearing fascicles of swimming-hairs, the last joint of the fourth pair having a simple aciculate termination; palpi subulate, setiferous, each second joint with a simple tooth-like projection developed on its under-side; genital plates evenly ovate or elliptical, each with three lineally disposed ovate acetabula; eyes forming two distinct pairs; ova deposited loosely within a common areolated matrix; larvae hexapod, sparsely hirsute, with two shorter antero- and four long postero-marginal setae; non-parasitic (?); nymph resembling the adult, but the genital plates bearing respectively but two acetabula. Type: *Limnesia histrionica* Herm. sp.

The characters afforded by the genital plates, combined with those of the epimera and the clawless terminations of the two posterior legs. renders *Limnesia* one of the most distinctly defined generic groups of the Hydrachnidae. The type-form of the genus, synonymous with the *Hydrachna histrionica* of Hermann, *Atax histrionus* of Duges, and *Limnesia fulgida* of C. L. Koch, is among the most abundant species in the neighbourhood of London, and has been specially selected by the writer for working out the anatomical features of the group. The ova and larvae of this species have been investigated, and likewise the nymph condition, hitherto unrecognised, but which has been found to be identical with the so-called *Limnesia cyanipes* of C. L. Koch, the transformation by ecdysis from one to the other having been frequently witnessed. The most important structural modification connected with this metamorphosis is manifested in the genital plates, which become transformed from the basally divaricant ovate plates each bearing two acetabula only of the nymph to the elliptical form with three acetabula on each side characteristic of the adult state. It is interesting to observe that the genus *Atax* proper is distinguished also in its nymph condition by a corresponding number of genital acetabula, while an identical structure and arrangement is diagnostic of the adult state in the genus *Atractides*. In addition to *Limnesia histrionica*, the writer has taken in the neighbourhood of London the *L. tigrina* of C. L. Koch and a third form apparently identical with the *L. undulata* of the same authority. Koch in his *Arachnidensystems* refers no less than twenty species to this genus, but there can be no doubt that many of these, as is the case with *L. cyanipes*, are merely nymph or immature phases of other forms. In addition to the distribution of the genital plates in the nymph of *L. histrionica*, here identified with Koch's above-named type, it is found that the characteristic swimming-fascicles of the adult are in a very rudimentary state of development, being represented indeed by only a few somewhat longer isolated hairs developed upon the two posterior pairs. A similar feature being distinctive of Koch's *L. vitellina*, *L. fenestrata*, *L. modesta*, *L. sacra*, *L. albella*, and *L. minutissima*, it seems highly probable that these all belong to some nymph category. His *L. longipalpis*, conspicuous for the abnormal length of its legs and palpi, is probably an example of a nymph recently exuviated to the adult form of probably such a type as *L. tigrina* or *L. hieroglyphica*. *L. histrionica*, immediately after the ecdysis, exhibits a corresponding long-limbed aspect. The remaining species figured and described by Koch which have apparently a sound claim for specific recognition are *L. maculata*, *L. oblonga*, *L. phoenicea*, *L. undulata*, *L. venustata*. His *L. rutilus* appears to the writer to be a variety only of the very variably coloured *L. histrionica*; his *L. attalica* identical with *L. cyanipes*, and therefore the nymph only of the last-named species; while Koch's *L. affinis* probably occupies a similar position with relation to *L. maculata*.

The species added to this genus by recent investigators include the Swedish *Limnesia pardina* and *L. marmorata* of Neuman. The *L. maculata* of Koch has been observed by both Neuman and Kramer, while the form referred to Koch's *L. undulata* by the last-named authority is, from the conformation of the genital plates, the nymph condition only of that or an allied species.*

---

* Unfortunately Saville-Kent never completed this paper, the remaining part being in the form of very rough notes without order. [C.D.S.]

ON METHODS OF ILLUMINATION.

By Edward M. Nelson, F.R.M.S.

(*Read May 23rd*, 1911.)

Mirror Illumination.—By this term is meant the illumination of an object by transmitted light with a plane or concave mirror without any substage condenser. This form of illumination was, up to a few years ago, very extensively employed, the use of a condenser, especially upon the Continent, being quite exceptional; in this country, however, condensers were more often to be seen. The medical student, the histologist and biologist never used any other kind of illumination; in fact, most medical students and biologists, even now, think that it was Prof. Abbe who invented the substage condenser. They are not aware that the achromatic condenser, in the form of an object-glass, was in use before Prof. Abbe was born; and ten years after its introduction a three-lens chromatic condenser, very similar to Prof. Abbe's, appeared, which failed to become established here because its achromatic rival was preferred. It should be noted also that a single-lens chromatic condenser had been fitted to all English microscopes of the better sort since Benjamin Martin's time (say 1775). There were plenty of condensers, but biologists would not use them. As the history of the condenser is not our subject, we will pass on at once to the mirror and the manner of using it.

Nearly all microscopes are now fitted with plane and concave mirrors, but a very few elementary instruments have only a concave; the plane is for use in conjunction with a substage condenser, and the concave for use by itself.

The ideal illumination for transmitted light is obtained when the object is at the apices of two conjugate solid cones of light.

An illumination such as that by parallel, or nearly parallel rays is to be avoided. Even that kind of illumination, now much in vogue with photomicrographers, which may be termed "lantern illumination," because the illuminating cone is focused upon the front lens of the objective, is to be deprecated; for it is only a method of obtaining an evenly illuminated field at the expense of loss of definition in the image.

But how does a medical student or biologist examine an object? He places his preparation on the stage and then fumbles about with the mirror until he succeeds in obtaining an evenly lighted field, and when he has got this he is quite satisfied. Let us follow his example, put our work to the test, and then note the result. Taking any object—say a blow-fly's tongue, an inch objective, and a low eyepiece—let us fumble about with the mirror until we have an evenly lighted field. If we now concentrate our attention upon one of the stronger hairs in the object, and with the coarse adjustment put it within and without the focus, it is ten chances to one that the out-of-focus coma will rock from side to side, or up and down, in the field, which shows us at once that our illuminating beam is not central. Turning now from the strong hair to the delicate ones on the membrane, we shall not find them imaged as sharp black spines, as they should be. The student will naturally ask what he should do. It would be unkind to refer him to one of the many treatises on the microscope, for the only information he will find on the subject will be: "Put it under, and, by moving the mirror, obtain an evenly lighted field"! The proper method of procedure is very simple. Focus the object; remove your eye from the eye-lens and look at it, not through it, and, by moving the mirror, bring the image of the light-source, be it window or lamp-flame, central in the eye-spot, or Ramsden disc. Now, when the image is tested by focal alteration, the coma will spread out equally on all sides of the image, and the delicate hairs will appear like sharp little thorns. Naturally the image will be inferior to that when a condenser is used, but a great difference will be noticed between those obtained with a centred and decentred mirror-image in the Ramsden disc. The student should remember that it is far better to have a centred illumination, even at the expense of an incompletely lighted field, than an evenly illuminated field and decentred illumination.

To illustrate this subject further, let the flat of the flame of a paraffin lamp be used as an illuminant, then, with concave-mirror illumination improperly arranged by a fumbler, the image in the Ramsden disc would very probably appear as in Fig. 1. The image of the flame resembles a decentred slit of light, notwithstanding that the flat of the flame is presented to the mirror.

It is this decentring of the illumination which causes the coma to rock upon focal adjustment. It is the asymmetrical arrangement of the beam passing through the objective which destroys the sharpness of the image, and it is the small W.A. (*i.e.* too large an unutilised area in the objective) which coats the image with black-and-white diffraction images. This image in the Ramsden disc (Fig. 1) should be compared with Fig. 2, which shows that the concave mirror is in correct adjustment, therefore the flat of the flame is imaged properly and centred to the disc. It does not take a single second of time longer to set the mirror properly than improperly. If a student knows what to do, he can do it, but at the present time he knows nothing whatever about it; and how should he when his instructor merely tells him to fumble about with the mirror until he gets a fully illuminated field?


1


2


3


4


5


6

Fig. 3 illustrates a properly-set-up illumination with the plane mirror. The only difference is that the image of the flat of the flame is smaller, and the unutilised portion of the objective larger; which is, as we have just seen, disadvantageous. With daylight illumination we must substitute image of window for image of lamp-flame. This image will vary according to circumstances. It may be, for instance, a gap between chimney-pots, or perhaps between houses; in my own case it is an irregular trapezium, formed by the top and one side of a window and a yew-tree. It is only a privileged few who have an unlimited area of unbroken sky, coupled with the idealistic and immovable white cloud. It is my unfortunate experience to find that white clouds always go just at the precise moment a delicate point is being caught, and then appears that terrible blue sky, so eagerly sought by many, but which drives a microscopist to distraction. It is remarkable that these fundamental principles of elementary microscopical manipulation have never been explained in any text-book on the subject.

The Ramsden disc is an image of the back lens of the objective. If the Ramsden disc be too small for examination by the unaided eye, the eyepiece may be removed and the back lens itself examined; but probably the simplest and quickest method is to employ a "loup," for it saves the trouble of removing and replacing the eyepiece.

Ground Glass.—Before dismissing this subject there is yet another kind of illumination to be dealt with, namely, that by ground glass. This illumination was largely used by Dr. Carpenter, and is much advocated by Lewis Wright in his admirable book on the microscope. I became first acquainted with ground glass in 1875, by purchasing a Swift's excellent Universal Condenser, which he had brought out the previous year. This condenser (an improvement on Hall's, made by Swift in 1868) I still have, and use.* The top lens is removable; the back, consist-

---

* So far as I am aware, these condensers were the first for low powers ever constructed, and the microscopical world is greatly indebted to the late James Swift, not only for them, but also for many excellent improvements, both in the brass and glass of the microscope.

This particular condenser is, I understand, no longer made; therefore a fuller description, showing wherein it differs from its modern substitute, is necessary. This condenser has an uncorrected front lens, and a pair of achromatised doublets at the back; therefore, when used as a whole, it is ing of two doublets, forms the best possible condenser for low-power work; a blue-glass light-modifier for lamplight fits below these lenses, and a ground glass (which is never used) fits above them in place of the top lens. Even to-day no better condenser is made for powers from $\frac{4}{10}$ in. downwards. Ground glass can be used with or without a substage condenser, but we are told that the orthodox method is to place a piece of finely ground glass upon the stage immediately below the slip.* Ground glass scatters the light it transmits in all directions, and therefore the objective will be working at full aperture. So far it would seem that, with daylight and the concave mirror, all control over the working aperture is lost; of course the light may be reduced by the iris, but obviously there is no means of varying the W.A. to, say, $\frac{3}{4}$ or $\frac{1}{2}$ cone. But if the unorthodox method of placing the ground glass behind a substage condenser is adopted, we shall find, by inspecting the back of the objective, that with the help of the iris we can regulate the working aperture of the objective. It would seem, therefore, that this position for the ground glass is a better one than that usually recommended.

With regard to its use with high powers the case is somewhat different; if with a 4-mm. apochromat a ground-glass screen, placed immediately behind the object, be illuminated by a substage condenser, and the iris fully opened, an image not very dissimilar to that when ordinary critical illumination is employed will be seen at the back of the objective (Fig. 4); but when the iris is closed a marked difference takes place, for the image then will not be of the ordinary form as in Fig. 5, but will be an

under-corrected, but nevertheless it makes a useful condenser for ordinary work with the medium powers (say, $\frac{1}{3}$ and $\frac{1}{2}$). When, however, the top is removed, a perfectly achromatic combination is obtained, which is, as I have already stated, the best ever constructed. Its modern substitute, for which that particularly fine combination of Baker's may be taken as a type, has also an uncorrected front lens; but the backs are over-corrected, and so the condenser as a whole is perfectly corrected. Now, when the top of this modern condenser is removed you do not find such a perfect low-power condenser as with the old form, because the combination is now over-corrected.

* Invented by John Keates, of Liverpool.

image of the source of light, in this case the edge of the flame (Fig. 6). This illumination is asymmetrical with regard to the aperture of the objective and therefore should be avoided. Now, what is the effect of the ground glass; does it improve or spoil the image? After exhaustive trials with lenses of various powers and apertures upon different objects the results may be summed up by one word "Fog." With ground glass the clear parts of the field are not so bright, and the dark parts are softer in tone than without it; in fine, the image, to use a photographic term, lacks the "pluck" of a critical picture, as if a thin veil had been spread over it. Ground glass gets rid of all necessity of centring the illuminating beam, for it is only necessary to place the mirror in such a way that light falls upon the ground glass anyhow. If the Ramsden disc be examined it will be found full of diffused light; further, the mirror may be moved about in various directions and, providing of course that the light is not turned altogether away from the ground glass, no change will be observed in the image, but if no ground glass is used the slightest displacement of the mirror from its proper position will decentre the image and mar the definition. While ground glass does not give the best results, it simplifies the manipulation; with medium and high powers a substage condenser should be used, otherwise the images will be poor. As this was being written, an achromatic $\frac{1}{4}$ in. of 0·77 N.A., with a coarse *Navicula lyra*, concave mirror ($2\frac{3}{4}$ in. in diam.) and daylight, without any condenser, was tried with and without ground glass. Poor as both images were, that without the ground glass was the better. The field lens (about 2 in. focus) of a B eyepiece was then placed below the stage, as a condenser, without ground glass, and it was found that the image was improved. If, then, the miserably poor image obtained from such an elementary form of condenser is better than that seen without it, we can understand how very bad the image with the ground glass must have been.

With low powers, window bars, moving clouds, chimney-pots, etc., are a trouble which ground glass will get rid of, but—and this should not be forgotten—at the expense of good definition. There is one more point before the trial of this kind of illumination is exhausted. It may be urged that while ground glass does not give such a good image as that obtained with a first-rate condenser, yet, if the condenser is a bad one, it will improve the image by neutralising some of its defects, such as chromatism and errors of centricity. To determine if this were so a very cheap condenser, consisting of two single plano-convex lenses, was tried with an achromatic $\frac{1}{4}$ in., with and without ground glass, and the image was found to be better without the ground glass. In the face of all these experiments Mr. Lewis Wright's predilection for this method of illumination astonishes one, for he did personally work with the microscope, and knew about critical images; on the other hand Dr. Carpenter's microscopy was of the biological kind, which had nothing more in it than putting it under, much in the same way as one would put a photograph in a stereoscope, so his advocacy of this imperfect method of work will cause no surprise.

Screens.—This subject would not be complete without a note on screens.* Formerly we all made a mistake by pitching our illumination too high up in the spectrum (I am now speaking of visual, not of photographic work). There can be no doubt about this, because fine detail is lost if the light is too high up in the spectrum. The cause is probably a physiological one. Experiments show that a normal eye is more sensitive in picking up fine detail when the light is a peacock green. Although with light high up in the spectrum the resolving power of a lens is increased, yet the sensibility of the eye is diminished. The art is to strike a happy mean between the two. Few microscopists, if any, have experimented more during the last thirty years with screens than I, and the following are three of the lessons I have learnt:

1. Not to work with light too high up in the spectrum.

---

* Screens were first introduced by Sir D. Brewster in 1836. His screne was a red one.

2. Not to form an opinion entirely by spectroscopic results.
3. Not to imagine that one screen is sufficient.

This is a difficult subject to deal with because words fail to convey even a rough idea of colour. Colours must be seen, but the following descriptions of screens which prolonged experiments have proved to be the best may be of assistance. For daylight, a piece of peacock-green, worked down so that it is not too deep in tint, is combined with a very light-blue glass not deeper in tint than a rather pale lilac petal. For lamplight, a thicker piece of peacock-green is combined with a blue glass, somewhat of the tint of the blue flower (*Centaurea cyanus*), common in cornfields. If these glasses * have been correctly chosen the microscopist after half a minute's work will not be aware of the presence of a screen. The best method of comparing the depths of the colours of screens is to place them upon a piece of white paper.

The ideal screen for visual microscopical work is one which, filtering out the too pronounced red, softens down, but does not entirely cut out, the orange and yellow lights. Twenty-five years ago any screen which did not pass certain spectroscopic tests, by absolutely cutting out all lights longer than a definite wave length, was rejected; now we know better. For example,

---

* I introduced and brought this combination to the notice of the Club in 1894. The tints were, however, deeper than those I now use, but in 1895 I stated that "if they are too dark they will obliterate fine detail, and it will be better to pass a wider band even should it contain some objectionable rays." So sixteen years ago I had recognised the principle of not being guided altogether by spectroscopic results.

The spectroscopic values of these two screens are as follows:

Daylight without any screen . . .	430 down to 680
„ with daylight screen . . .	430 „ 630
Lamplight with lamplight screen . .	450 „ 620

This information for visual purposes is valueless, although it looks so scientific, because it does not indicate how much the orange and yellow lights have been toned down. Although the red is only reduced by 10 with the lamplight screen, yet the effect of this screen is very much greater than it appears, owing to the toning down of the orange and yellow. The only method whereby screens could be standardised, or rather their value expressed numerically, would be by Mr. J. Lovibond's tintometer.

if an insect preparation is viewed through a screen which cuts out all below the yellow, the orange-yellow colours, peculiar to that class of objects, are darkened out of all recognition. This is just where the art comes in of constructing a screen which shall remove every thing objectionable and leave that which is necessary for the proper observation of the object. The fact is that our heads were swelled by the "table of resolving powers" published on the cover of the *R. M. S. Journal*, where the three selected lights had wave lengths of 5,269 for visual, line F 4,861 for screen, and 4,000 for photography.* I altered the visual to Gifford's maximum 5,607, and photography to 4,341; this last should be brought still lower down the spectrum to the photographic maximum through glass, of 4,603, and the screen placed at least as low down as b, or 5,184, if not lower.

Gifford's screen is formed by placing a piece of worked-down peacock-green glass in glycerine coloured by malachite green. The solution may be made so strong that a very shallow trough is sufficient. A disc of peacock-green glass may be edged so as to fit in the carrier below the substage condenser; a cell, made by a metal ring, filled by the solution and covered by a thin covering-glass in the usual way, precisely like a preparation in a fluid mounted slide. Screens mounted in this manner are very delicate, and may in time leak. I used them extensively, but afterwards placed the fluid and the glass in a Leybold's cell, 0·2 in. thick, on a separate stand.

Dr. Miethe's screen consists of a saturated solution of acetate of copper in a Leybold's cell, 0·8 in. thick. To this I added an interior trough, 0·2 in. thick, filled with water coloured by methyl blue. This screen when used with lamplight should be thicker, and the water bluer, than for use with daylight. The poisonous and corrosive nature of acetate of copper is the great disadvantage of this screen, which, notwithstanding its excellent

---

* *J. R. M. S.* 1885, p. 972—where the photographic resolving limit is put at 127,000 lines for N.A. 1·0 !

quality, is not much in favour with microscopists. Glass is simpler, more portable and cleaner.

Screens for sunlight with heliostat, for oxyhydrogen light and for photographic purposes are different, and are beyond the limit of this article.

Spectrum.—There is another method of illumination, viz. that of using the spectrum, or rather a portion of the spectrum, itself; this I have described elsewhere, so will not repeat. A prism spectrum is better for this purpose than a grating, for a prism forms only one spectrum, and all the light which is dispersed goes into it; on the other hand, a grating makes several spectra, and, as only one of them can be used, much light is lost, but the dispersion of a Rowland's 14,400-line grating between E and G lines in a spectrum of the first order is more than double that of an ordinary flint prism.

ON SOME RHIZOPODS FROM SIERRA LEONE.

By Dr. E. Penard, of Geneva.

(*Read June 27th*, 1911.)

Plates 9 and 10.

I am indebted to Mr. G. H. Wailes for some sediment which was collected by his brother, Major W. E. Wailes, from a "slow, large river containing weeds" at Sierra Leone.

In the material which I examined, fourteen species of freshwater Rhizopods were found; and as three of them are new, and four at least might be considered as special forms or varieties, it is desirable, I think, to give here, with the kind permission of Mr. Wailes, the result of my observations.*

The species found were the following:

Centropyxis aculeata Stein.
,, *arcelloides* Penard.
Difflugia acuminata Ehrenberg.
,, *constricta* (Ehrenberg) Leidy.
,, *echinulata* sp. nov.
,, *lingula* sp. nov.
,, *pyriformis* Perty.
Euglypha alveolata Dujardin.
,, *laevis* (?) Perty.
Lesquereusia mimetica sp. nov.
,, *modesta* Rhumbler.
,, *spiralis* (Ehrenberg) Bütschli.
Pontigulasia compressa (Carter) Cash.
,, *vas* (Leidy) Schouteden.

Of these fourteen species, seven, as said before, might be considered as showing the normal type; and yet none of these seven was absolutely typical. *Centropyxis aculeata*, *Lesquereusia modesta*,

---

* The material was very scanty, and I have no doubt that this list of fourteen species does not give a full idea of what was contained in the original collection. Mr. Wailes, I hear, will very likely receive more, from different parts of the colony; certainly he will be able to add many species to the list and to prepare, I hope, an important report on the subject.

were small varieties; *Euglypha alveolata* much smaller than the type; and as for *Euglypha laevis*, or what I considered as such, it was very thin and inconspicuous, and I could not arrive at a definite conclusion about it. Of *Difflugia constricta* there were two varieties, both with elongated tests; a typical *Difflugia acuminata* was found, but two other forms existed also—var. *inflata* Penard, and a very short, nearly spherical and sharply pointed variety. *Pontigulasia vas* was a variety, or rather there were two varieties, both extremely small.

Much more curious are the following:

? **Centropyxis arcelloides** Penard (Pl. 9, Figs. 1, 2).

Only when making allowance for a very large amount of specific variability could the Sierra Leone specimens be considered as belonging to this species; in fact, they might represent something else, autonomous types; and not only one, but *two* species rather than one, for the tests—very numerous but always empty—could be found under two different aspects, and without any transition between them.

Fig. 1 shows the first of these forms, flat discs, where, as a rule, no opening could be detected, and which hardly looked like the test of a Rhizopod. A further examination, however, showed a dorsal and a ventral aspect, this latter slightly invaginated, and provided with a narrow central opening. The tests, 187 to 209 μ broad, were composed of small flat sand particles imbedded in a colourless chitinoid material.

The second form (Fig. 2), with a test of the same structure, was much larger, 330 to 380 μ in diameter, with a higher, regularly convex dome, and a flattened ventral face; the central orifice was very large, more than half the entire breadth of the shell, and with a distinctly crenulated margin.

Pontigulasia compressa (Carter) Cash (Pl. 9, Fig. 3).

This species was fairly well represented, but the specimens, of a larger average size than the type (200 to 220 μ, instead of about 100), and which in fact might as well have been referred to that big lacustrine form which was described as *Pontigulasia bigibbosa* Penard, showed a peculiar appearance, which seems not to have been noticed anywhere before.

The line of junction of the test-body with the neck, which normally figures as a dark curved line (see Cash, *Brit. Freshw. Rhiz.*, vol. ii. p. 63), was here of a very peculiar design, a deep notch, with angular corners, such as shown in Fig. 3*a*. In Fig. 3*b* this characteristic is seen from the side, but drawn from a much smaller specimen.

This species, indeed, was represented in the collection by two forms—the large one which has been considered here, and a smaller one, about 150 μ in length (Fig. 3*b*), and it was on the smaller tests that the peculiar marking was mostly sharply exhibited.

Lesquereusia spiralis (Ehrenb.) Bütschli (Pl. 9, Fig. 4).

This species was represented by two very distinct varieties, both of which are always of very rare occurrence; the second (Fig. 4*b*), indeed, though reminding one of some of Leidy's figures (*Freshw. Rhizop. of North America*, pl. xix, figs. 9, 10 and others), hardly seems to have been described yet.

In the first of these varieties (Fig. 4*a*), the test, thin and transparent, 95 to 100 μ in length, covered with small and relatively short vermiform rods, which were disposed with some regularity in parallel rows, was ovoid in outline, slightly compressed, and provided with a short neck, affixed to the body of the shell and running along it nearly its entire length, hardly showing, in fact, anything like the typical form of a tube.

The second variety (Fig. 4*b*), larger (135 to 140 μ), and with a network of very long, thin, narrow rods, was quite different in appearance, with a nearly globose body, from the anterior part of which arose, in a tangential direction, a straight, very broad, tubular neck, opening in a large orifice, somewhat elliptical in its contour.

Difflugia pyriformis Perty (Pl. 10, Fig. 5).

In the group comprising the numerous Rhizopods which, though very likely representing genuine species, have a pyriform appearance, and very generally described as *Difflugia pyriformis* Perty (*D. oblonga* Ehrenb. in Cash, vol. ii. p. 5), I must include, in the absence of any further information about the living body, a small Rhizopod whose tests, all quite identical, were found in the material.

The shell (fig. 5*a*), about 128 μ in length, whilst showing the ordinary pyriform appearance, is relatively very narrow, tapering into a very long, straight neck, which abruptly terminates in an orifice bordered by a thin, transparent, somewhat curved rim or lip (Fig. 5*c*). This appearance of a lip-like border, which could be seen on all the specimens, is quite peculiar to itself and has never been observed in any variety of *D. pyriformis.*

The test itself is thin, chitinous with cemented flat grains—mud particles—and somewhat compressed, so that a transverse section, through the middle of the test, would figure as an ellipse, the small axis of which would measure about three-fourths of the long one.

Fig. 55 shows the test as seen from the side.

Difflugia lingula sp. nov. (Pl. 10, Fig. 6).

This Rhizopod also reminds one at first sight of some varieties of *D. pyriformis*, and one might easily be tempted to refer it to the figures 14, 15, 16, pl. xii. of Leidy's great work; but it is much larger, more compressed, smoother, and shows a peculiar appearance which points to a distinct species.

Seen from the broader side (Fig. 6*a*), the test, 220 to 240 μ in length and about 170 μ broad, and covered with flat siliceous particles, has a cordiform or linguiform appearance. It is regularly rounded on its sides, and from a little behind its middle it tapers rapidly to an abrupt, relatively narrow, circular (not compressed) orifice. Posteriorly, the shell is terminated by a sort of keel or apex, which is very often eccentrical, being displaced left or right; very rarely there is no appearance of an apex, and the two sides simply meet each other abruptly, forming an angle.

The test is much flattened, and from above shows an elongated elliptical contour, the length of the ellipse being about double its breadth (Fig. 6*c*, where the circular mouth is seen in the middle). In Fig. 6*b* the shell is seen laterally.

This species was rare in the collection; about twenty specimens, however, were found. All the tests were empty, or only contained some dried, decayed yellowish matter, all that was left of the plasma.

Lesquereusia mimetica sp. nov. (Pl. 10, Fig. 7).

This very remarkable Rhizopod, whose structure presents something unwonted and strange, is at the same time one of the largest, attaining on an average about 400 μ in length; but, curiously enough, and just like what we saw when treating of *Pontigulasia compressa*, two series were found, one embracing specimens varying from 370 to 420 μ in length, the other much smaller, about 310 μ. Some transitional cases, however, were found, but they were very few.*

The test (Fig. 7), built of siliceous sand particles imbedded in a chitinoid material, looks at first sight like an ovoid, slightly compressed, Difflugia shell, about one and a half times as long as broad, rounded behind and tapering anteriorly into a terminal, circular mouth.

But a more thorough examination proves the structure to be quite different. From below one of the corners of the terminal orifice a dark line is seen, going down towards the posterior part of the shell, cutting, in appearance, the test in a direction parallel to the side opposed to the starting-point of that line, and terminating abruptly somewhat behind the middle of the shell.

This line represents, in fact, an inside partition, yellowish, chitinous, yet mixed with very small siliceous particles; and this partition is double (at least must be originally), an inner sheet representing the body envelope, an outer one the ventral wall of the tube characteristic of the genus *Lesquereusia*.

The long tube, in fact, has been pressed against the shell, soldered to it; everything, at the same time, has been smoothed

---

* This existence of two parallel series in a given locality, if exceptional, is not very rare among Rhizopods. Without pretending to give any serious explanation of the fact, I surmise that in such cases one has to do with two "generations." The testaceous Rhizopods divide, perhaps several times in a season, the plasma building a new shell where part of the contents of the old are introduced, and, when conditions are favourable, that new shell is a trifle larger than the old. After five or six divisions, the last-formed tests are much bigger than the first original ones; and a time comes when nearly all specimens in a given station have attained what might be called an optimum, which cannot be exceeded in that station. But it might happen that in the very same locality, "little ones" have been produced in the meantime (from spores (?) or cysts (?)), and these, having not yet attained the optimum, can be sharply distinguished from the old generation.

in the contour of the test, so far as to conceal all appearance of a typical *Lesquereusia*.*

Something, however, of the original generic type is very often to be seen, a big transparent particle, or several small ones, filling a kind of notch behind the mouth, the space, in fact, left between the free extremity of the tube and the body of the shell (Fig. 7*a*).

The specimens were not rare, but, like everything else in the collection, the plasma was dead and decayed; something of its form, however, could now and then be distinguished, and, for instance, in Fig. 7 one sees the bulk of the plasma, with a strip of ectoplasm which goes along and inside the tube and expands at the mouth.

Difflugia echinulata sp. nov. (Pl. 10, Fig. 8).

If *Lesquereusia mimetica* showed a very peculiar appearance, the Rhizopod which is to be described now is perhaps more curious still, in so far as it is the only known typical *Difflugia* which is provided with spines all along its shell.

The test, 140 to 145 μ in length (one specimen was only 130 μ), might be called indifferently ovoid or cylindrical, having the form of a finger, or of an acorn (Fig. 8*a*). About twice as long as broad, rounded behind, a little narrower at the anterior end, and terminating in a circular opening, it is chitinous, transparent, colourless or yellowish, and covered with siliceous particles, most of which are very minute and form a kind of felt, whilst some larger ones are disposed here and there at the surface. This test is rounded, not compressed, a transverse section giving a perfectly circular figure (Fig. 8*b*).

But all around the test, beginning just behind the mouth and going down to the fundus, chitinous spines are disposed here and there, without any symmetrical arrangement; they are very variable in number, generally a dozen or more, and in length also, most of them being half as long as the shell is broad. The structure of these spines is quite peculiar. They are not the result of a simple exudation of the shell, but of a develop-

---

* In many of the specimens—which were all dead and filled with decayed plasma—this peculiar structure was very indistinct; but after leaving the tests for a few minutes in concentrated sulphuric acid, all became clear and very distinctly visible.

ment of the shell itself, a kind of "devagination," the chitinous envelope being in some way pushed out at certain points, in the shape of a long, narrow tube.

Sometimes the tube is pointed, simply closed at its extremity (Fig. 8*c*), but much more commonly it retains its breadth to the very end, or even expands, and is terminated by some foreign particle taken from the mud; these particles, always clear and transparent, have the shape of a knife (*d*, *e*), or of an arrowhead (*f*); sometimes a small diatom is recognisable, or the form is very queer (*g*), and often the particles were small, shining coral-like bodies (*h*, *i*), which were found also isolated in the mud, and whose nature I could not decide upon.

This species was very rare; about a dozen specimens were found, and only seven could be examined and studied with ease; all were alike, and the nature of the spines was always the same.

Like the other Rhizopods of the collection, the shells were empty or filled by some decayed, yellowish remnant of the plasma.

Almost certainly we have here a *Difflugia*; but should the pseudopodia be filamentous, this species would belong to the *Filosa*, and come very near the genus *Pseudodifflugia*.

Fragmentary as have been the results of these preliminary investigations, they allow of some general deductions, which go to confirm the views of such observers as have had opportunities of studying collections from all parts of the world.

First, if most of the Rhizopods are common in many and very distant countries, and with such characters as are sufficiently alike to allow of recognising their specific identity, some difference, however, may always be expected from one station to another; difference in shape, in size, in structure; mostly so slight as not to be easily expressed by word or sketch, but sometimes sharp enough to point to a distinct variety. The Rhizopods, in fact, like all other living beings, vary, according to the station, and produce local forms, which are preserved in the locality.

Secondly, if all the recent contributions to the study of these organisms have confirmed the "cosmopolite" theory of their distribution, we must yet come to an understanding as to the meaning of the word. They are cosmopolitan in so far as, sufficiently favourable conditions being given for a prosperous existence, there is a good probability of their being found; but they are not cosmopolitan in reality, for many species are confined to a very limited area; such-and-such a species, for instance, described from some island in the Pacific Ocean, will have no chance at all of being found in Europe.

But Rhizopods, like other Protozoa, have this privilege, that one at least of the reasons that exclude higher animals from many countries, namely, difficulty of transportation, has no, or a very feeble, rôle to play in their case.

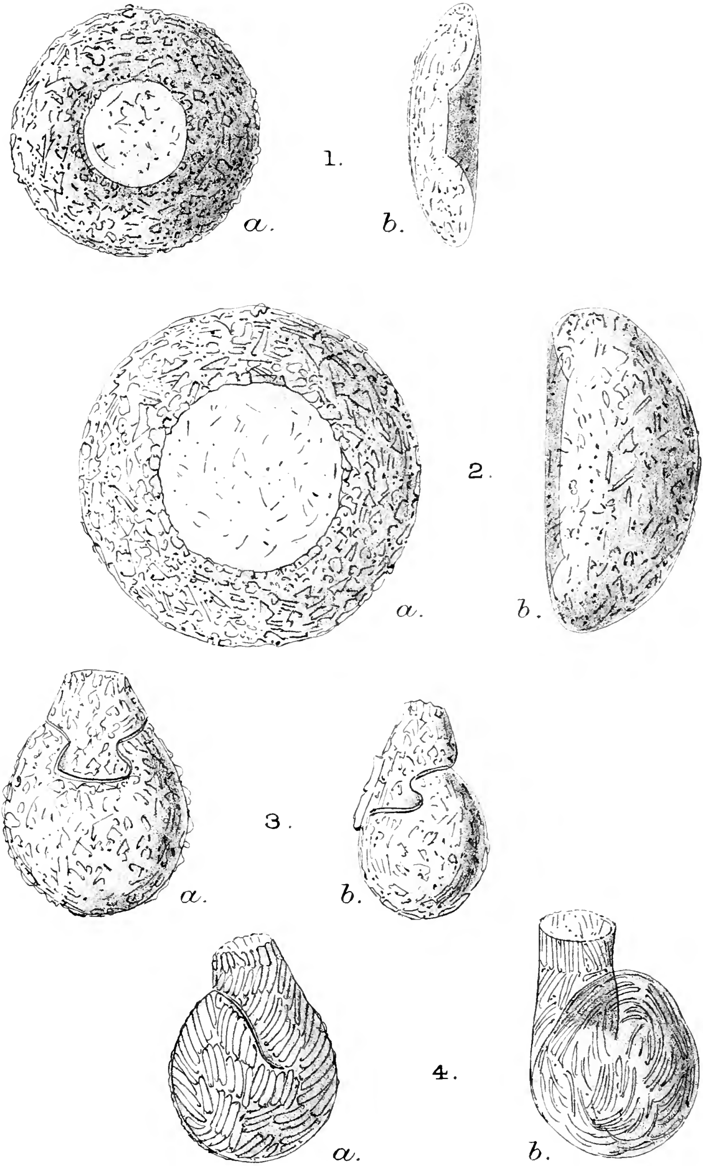
If, before the arrival of Europeans, rabbits, to take an example, were not found in Australia, where they came afterwards to live only too well, this was owing to the impossibility of their coming; but Protozoa will go everywhere, be transported to any distance by wind. Only they must fall on the right place; most of them, truly, will be content with any pond or swamp, but others must have the moss of big forests, woods, or the walls of old ruins, or sphagnum, or the pure water of glacial lakes, etc., and, in the case of our Sierra Leone Rhizopods, one might ask if the conditions for their prosperity would not be: slow river, warm water in a torrid, damp climate?

As such conditions can only be fulfilled in a very limited number of stations, and the investigation of such countries as the tropical coast of West Africa has been until now, as regards Rhizopods, next to nothing, good results might be expected from a thorough examination of further collections. I hope, for my part, that Mr. G. H. Wailes will find time and opportunity to study the subject, and that the present short notice will be followed by more complete and important descriptions.

DESCRIPTION OF PLATES 9 AND 10.

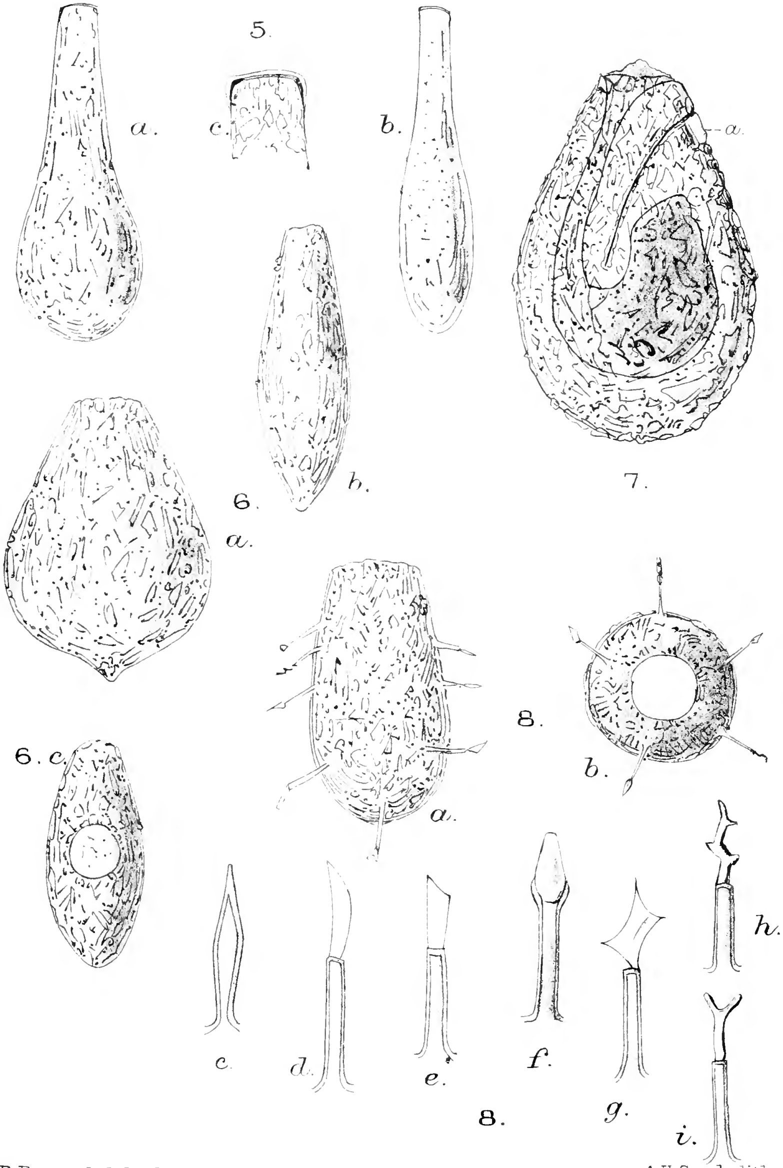
Fig. 1. ? *Centropyxis arcelloides.*
,, 2. ? ,, ,,
,, 3. *Pontigulasia compressa.*
,, 4. *Lesquereusia spiralis.*

,, 5. *Difflugia pyriformis*, var.
,, 6. ,, *lingula.*
,, 7. *Lesquereusia mimetica.*
,, 8. *Difflugia echinulata.*



Penard del. ad nat. A.H. Searle lith.

Rhizopods from Sierra Leone.



E.Penard del.ad nat. A.H.Searle lith.

Rhizopods from Sierra Leone.

SOME NOTES ON SEEDS AS MICROSCOPIC OBJECTS.

By N. E. Brown.

(*Read April 25th*, 1911.)

The following notes are written in the hope that they may prove of interest to those who are on the look-out for what are popularly termed "good objects."

Possibly many who read this will have limited their examination of seeds more or less to the lists of genera given in the *Micrographic Dictionary* and elsewhere, without having any idea of the many elegant kinds that are not mentioned. Among those enumerated in such lists are some that are decidedly worth preserving as objects of beauty, but there are many others that seem to me of very ordinary pretensions and scarcely worth the trouble of mounting. Those I am about to mention, however, will be found to be either really attractive or interesting on account of their form and structure, and all of them worth the trouble of preserving. A few may be familiar to some microscopists, but to the majority, I believe, they are not well known. Some of them can be easily obtained, others will be much more difficult to procure, because in some cases the plants are only cultivated where a large general collection is grown; in others, as in the case of the magnificent golden seeds of *Picrorhiza Kurrooa*, they are only occasionally introduced and the plant soon dies out of cultivation, often without ripening seed, so that they must be procured as opportunity offers. A few of them have never been introduced into cultivation, and must be obtained from botanical friends residing in their native country.

In preparing and exhibiting them, I find that I get the best results by the following method. I mount them in cells, dry, on clear glass slips, not on a dark background, fixing them with a minute speck of seccotine or gum; if the latter, I proceed by brushing a thin layer of it upon a piece of card or paper, then, holding the seed in a pair of fine forceps, just let it touch the gummed surface and transfer it to its place on the slide. If they are mounted in balsam or other medium I consider their beauty is much deteriorated. For illuminating them, I prefer incandescent gaslight, as that from a lamp is not sufficient to give the best results. Place a spot-lens beneath the stage and focus the light from the concave (not the flat) mirror on to the seed, then with a condenser (one without blue glass) focus the light upon the seed from above. This arrangement will exhibit the seed in its natural tints, but if a coloured sheet of gelatine (say red) is held close under the spot-lens and a sheet of another colour (say green) is held over the condenser, then the beauty of some of the seeds mentioned here is doubly increased and their details sharpened by contrast. These coloured sheets of gelatine are easily obtained from an optician at a very small cost, and I believe that those who have never made use of them in the manner above detailed will be pleased with the enhanced beauty and probably appreciate the distinctness of detail they give to many objects, such as small star-fish, etc., especially if viewed under a binocular. The latter effect has been remarked by all to whom I have shown this method. By reversing or varying the colours employed, various charming effects may be obtained, which are totally different from those produced by Mr. Rheinberg's method. In that the object is seen in only one colour, surrounded by a field of another colour; in the method here detailed the object is seen in two colours upon a black background. This kind of illumination may not be new, but does not seem to be generally known.

As it sometimes happens that an object wanted cannot always be obtained correctly named, instead of merely enumerating the names of a few seeds I have added a brief descriptive note to each, whereby it may be known when the right species has been obtained.

Eucharidium concinnum (Onagraceae).—Select a pair of seeds of equal size, mount them side by side, as above directed, with that side uppermost in which a hole is present. When examined you will find them to resemble a very neat pair of brown "lace-up" shoes, with the margin around the top and down the edges for lacing up very prettily scalloped; tongue-piece and all is represented, and the substance of the "uppers" is somewhat sculptured. If a red sheet of gelatine be interposed between the mirror and spot-lens and a green sheet over the condenser, the soles of the shoes are outlined in red and the "uppers" in green in a manner that is very effective. A native of California; cultivated in some gardens.

Datisca cannabina (Datiscaceae).—This plant has seeds which resemble small bottles, covered with a coarse network.

A native of the Orient, extending into the north-west Himalaya; it is occasionally met with in cultivation.

Cephalipterum Drummondii (Compositae).—In this case it is not the seed itself, but the pappus with which it is crowned that claims our attention. The hairs of the pappus are bright lemon yellow and in form something like a small feather dusting-brush, having a flattened stalk or shaft with short spine-like hairs along each edge, with the top terminating in a thick tuft of spreading and recurving hairs. A native of Western Australia, and not in cultivation.

Pterospora andromedea (Monotropeae).—If seeds were classified according to their beauty, this plant would assuredly be mentioned with those in the front rank. The body of the seed is very minute, of a dull yellow-brown colour, ellipsoid in form, with numerous longitudinal ridges; at one end it expands into an elegant fan-shaped membrane of white gauze-like network, many times larger than the body of the seed, and forms a beautiful appendage to it, which is doubtless of use in aiding its dispersal by wind. A native of North America; not in cultivation.

Nemesia strumosa (Scrophulariaceae).—This common garden plant has one of the most beautiful seeds known to me. A broad wing of elegant lace-like structure surrounds the body of the seed, which is covered with a deeply honeycombed structure, having the cells compressed lengthwise to the seed, and mingled with or arising from them are several short inflated club-shaped processes marked with spiral thickenings on their cell-walls, all of which are pure white.

Several species of this genus have very pretty seeds, but I have seen none that are more beautiful than those of *N. strumosa*, which, apart from its seeds, is remarkable for the very great range of variability in the colour of its flowers in a wild state. The first year of its introduction into this country, plants grown from wild seeds produced over fifteen distinct variations of colour. It is a native of Cape Colony.

Picrorhiza Kurrooa (Scrophulariaceae).—The seeds of this plant may to a certain extent be compared with the painted actress as seen on the stage, and at short range in broad daylight. For when viewed with artificial light, arranged as above mentioned, these seeds are very beautiful, but are not seen to such advantage and may even seem somewhat disappointing when viewed by daylight. Here we have the narrowly ellipsoid body of the seed suspended within and to one side of a large inflated network, puckered into irregular folds, resembling, under reflected light, an irregularly crumpled bag of golden network with iridescent reflections.

Paulownia imperialis and **P. Fortunei** (Scrophulariaceae).—The seeds of these two trees are very similar, but differ in size. *P. imperialis* is a native of Japan, not infrequently cultivated, and has the smaller and rather whiter seeds, but both are exceedingly beautiful. The narrow brown body of the seed is longitudinally traversed by slightly elevated ridges or crests of fine network, and surrounded by a broad irregular whitish wing, deeply notched at each end. This wing is formed of two or three layers of different breadths of beautiful lace-like tissue, and when illuminated as above noted these seeds make lovely objects. *P. Fortunei* is a Chinese species.

Angelonia salicariaefolia (Scrophulariaceae).—The seeds of this plant are about twice as long as broad, pyramidal in form and coarsely reticulated all over, with the reticulations raised into several longitudinal zigzag somewhat wing-like ridges. In an allied species (*A. integerrima*) the substance filling the areas of the reticulations is of very fine lace-work. All are natives of Tropical America and some of them not uncommon; the above and some others are occasionally seen in cultivation.

Orthocarpus australis (Scrophulariaceae).—This plant has rather peculiar seeds, the testa resembling a small balloon of elegant pale-brown network, in the centre of which is suspended the small narrowly ellipsoid dark-brown body of the seed, like a bird in a cage. A native of Chili, and not in cultivation. Other species of *Orthocarpus* have seeds built upon a similar plan, some being quite as pretty, whilst others again are sculptured somewhat as in *Angelonia*, but quite different in shape. There are many species of this genus in California and the Rocky Mountains, but none are in cultivation.

Sesamum capense (Pedalineae).—The saying "open sesame" is familiar to us all, but probably few microscopists are as familiar with the seeds of the plants from which that saying is derived, or if they are, have possibly only seen seeds of such species as have no wing surrounding them, and which are neither attractive nor interesting objects. But the seed of *S. capense* is an exception, for although not what would be considered a beautiful seed, it is certainly an interesting one, on account of its structure. The ovate flattened dark-brown body of the seed is shallowly honeycombed and minutely tuberculate all over and surrounded by a broad semi-transparent reticulated pale-brown wing, which is divided into three lobes by a notch on each side and another at one end; at the sides the lobes overlap, but at the end they only meet; half the breadth or less of the wing is minutely tuberculated. If coloured films of gelatine are interposed, as previously directed, this seed forms a very pretty object. A native of South Africa; not in cultivation, unless perhaps under a wrong name.

Aeschynanthus grandiflorus, Ae. Lobbii, and other spp. (Gesneraceae).—Although not beautiful, the minute seeds of various species of this genus are remarkable for having a long hair-like tail at each end, and the body of the seed is sometimes peculiarly tuberculate. All are natives of Tropical Asia and the Malay Archipelago; the above named and some others are in cultivation.

Philydrum lanuginosum (Philydraceae).—In this plant the seeds resemble small vases of deep garnet-coloured or sometimes brown glass, with numerous ribs spirally twisted around them and covered with small knobs. A native of China, Malaya, and North Australia; cultivated in some gardens.

Lopholepis ornithocephala (Gramineae).—Here again it is not the seed itself, but the glumes in which it is enclosed that are remarkable. For, as in many grasses, the seed does not become free and fall out, but remains enclosed in the glumes of the flower, which in this plant resemble a bird's head, having a toothed crest on the top of the head and along the upper and lower edges of the beak, with the sides of the head and the laterally compressed beak covered with small tubercles. This makes a very remarkable and interesting object, but is very difficult to obtain. It is a native of the Deccan Peninsula, where it is common, but is not in cultivation.

Elionurus elegans (Gramineae).—Another grass, of which the glumes make very elegant low-power objects. The outer glume is ovate, acute, and ends in two bristles; whilst the margin on each side has a series of stout tubercles projecting from it, each tubercle bearing a tuft of long pure white hairs, forming a beautiful marginal fringe; there is also a tuft of similar hairs on the back of the pale-brown glume at its base. A native of west Tropical Africa, not in cultivation. Some other species, also natives of Tropical and South Africa, have glumes resembling the above.

Finally, the familiar **Brazil Nut** is a seed of some interest to microscopists, although I have not met with more than two or three who have considered it worthy of their attention. A thin section of the edible part, nicely stained, will exhibit aleurone grains to perfection, whilst a section of the shell makes quite an interesting object, especially if taken near one end of the nut, where, upon breaking the shell, an inner pale-coloured layer is sometimes seen. A section at this point shows an outer layer of transverse elongated cells, with their longer axis perpendicular to the surface; next a middle layer of very irregularly formed cells with thick red-brown walls; and an inner layer of transparent cells with very thick walls and of a very remarkable compound structure, as if with four or five centres. Also the Brazil nut sometimes, although rarely, undergoes a chemical change, possibly due to some disease, whereby white crystals are formed within it. If these crystals are melted and mounted they form an extremely beautiful polariscope object, one that can scarcely be surpassed. Another feature of interest, but in no way connected with microscopy, is the manner in which the germination of the Brazil nut aptly illustrates the doctrine of the "survival of the *strongest*." When ripe, the nuts are enclosed in a subglobose seed-vessel, 5–6 in. in diameter, with a wall about half an inch thick and very hard, closed by a small lid at the apex, which adheres so tightly that upon the fall of the fruit, perhaps from a height of 100 ft., it does not become detached, nor does the fruit break open, and water cannot penetrate it. After about eighteen months the seeds germinate inside the fruit, the young stems make their way to the lid, and after a while it either becomes detached or is forced off, leaving a small hole through which the young seedlings find their way. As it takes four to six years for the hard case of the fruit to decay, each seedling strives for the mastery and the weaker become strangled in the hole in succession by the stronger, until only one, the victor, is left. Originally the fruit contains from fourteen to twenty-one nuts.

DIMORPHISM IN THE SPERMATOZOA OF THE FLEA AND BLOW-FLY.

By T. A. O'Donohoe, I.S.O.

(*Read June 27th,* 1911.)

Plate 11.

If the testis of a flea (*Pulex hominis*) be placed in a drop of water on a clean slide and punctured with a fine needle, under a low power, fine hair-like organisms will be seen to burst forth, and by gently moving the testis these are easily spread about on the slide, so that when the drop of water is allowed to dry up these minute organisms can be stained in dilute carbol-fuchsine or gentian violet, and mounted in Canada balsam for examination.

A slide thus prepared was hurriedly shown by me some weeks ago at one of our Gossip Meetings. This I did before carefully examining the preparation myself, so that on looking at it more carefully on the following day I was much surprised to find that these spermatozoa differed very much both as to form and size, that in fact there were two distinct kinds. At that time I was not aware that any animal was endowed with more than one kind of spermatozoon, and some of my friends suggested that the two forms which I had discovered in one flea were nothing more than developments of one form.

This seemed to me at that time a reasonable objection; but finding that a flea caught in the act of copulation yielded the same two forms, this objection became untenable inasmuch as the spermatozoa would, in my opinion, be fully matured in such a flea. With a view to learning whether cases of dimorphism in the spermatozoa of animals were recorded I had recourse to several volumes of the *Journ. R. M. S.*, in which I found extracts from various writers showing that in some animals two forms of spermatozoa were undoubtedly found. I will quote one of these extracts, which will be enough for my purpose: "A. Gruvel brings together some of the cases of dimorphic spermatozoa in *Paludina vivipara*, *Notommata sieboldii*, *Asellus aquaticus*, *Pygaera bucephala*, *Staphylinus* and *Cybister roesellii*" (*Journ. R. M. S.*, 1905, p. 34).

It now became quite clear to me that the common house pest, the flea, is one of the animals provided with two kinds of spermatozoa, but further examination has shown that all are not so endowed, but only about 70 per cent.; in the remaining 30 per cent. I find the smaller form only. This smaller form I find in all, and in all it is more numerous than the larger form. The spermatozoa of the flea are very large compared with those of man, whose spermatozoa, according to Schäfer, have an average length of about $\frac{1}{400}$ in. (0·06 mm.). In the flea the larger form is $\frac{1}{36}$ in. to $\frac{1}{56}$ in. long (0·7 mm. to 0·45 mm.), and the smaller form is about half these lengths.

They can be seen with a 1-in. objective, but a fine $\frac{1}{12}$-in. is required to make out their structure. Both forms are hair-like with sharp pointed heads, the anterior part of which never stains whilst the second part stains well. Both forms are alike as to the heads, but differ in the length and form of the body, which in the smaller form tapers gradually from the head and ends in a fine line, whereas the body of the larger form gradually increases in size and ends in a bulbous swelling.

The body in both forms is composed of the following three parts:

1. The membrane proper of the body, extending from the head to the distal end.

2. An undulating filament which starts from the back of the head and winds around the body externally; this is visible in the small form throughout the whole length of the body and projects a little beyond, but in the larger form it is lost sight of about half-way and seen again projecting beyond the bulb-like end.

3. A fine filament winding as a spiral inside the body of the spermatozoon. This is very difficult to see or photograph and is visible only in some of the individuals.

Of this fine filament Mr. Nelson writes: "The finer structure shown in your photomicrograph is a true spiral which undoubtedly is inside the thread-shaped body. There seem to be five or five and a half turns of this small spiral to one undulation of the exterior ribbon."

I have also examined the spermatozoa of the blow-fly obtained from the spermatheca of a female. They are much smaller than those of a flea. There are two forms which do not differ much in length, which is about $\frac{1}{200}$ in. (0·12 mm.), but one is very much thicker than the other; indeed, this other is possessed of such extreme tenuity that it reminds me of Euclid's definition of a line, *i.e.* "length without breadth."

The heads are pointed and the bodies, like those of the flea, are composed of three parts which can be seen only where they seem to have separated accidentally. The two filaments which wind in the spermatozoon of the flea do not wind in that of the blow-fly.

This dimorphism in spermatozoa when considered in conjunction with the well-established dimorphism in ova seems to indicate that sex goes much deeper into the act of generation than is generally supposed, that in fact a male spermatozoon may be attracted by a female ovum or that a female spermatozoon may unite itself to a male ovum. This is a problem for a definite solution of which scientists will probably require a much more perfect microscope than those which we possess to-day.

DESCRIPTION OF PLATE 11.

Fig. 1. Shows three distal ends indicated by their whip-like filaments. The bulb-like ending of the large form is easily distinguished from the ends of the two smaller forms. The undulating filament is also well seen, × 1500.

Fig. 2. Shows the fine internal spiral in three of the spermatozoa of the flea, × 1500.

,, 3. The large form of the spermatozoon of the blow-fly showing the three filaments of which it is composed, × 900.

,, 4. In the centre is seen the head of a spermatozoon of a flea, × 900.

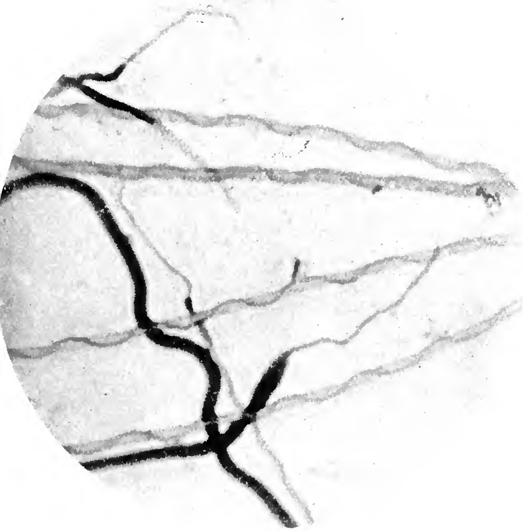


Fig. 1.

Fig. 3.

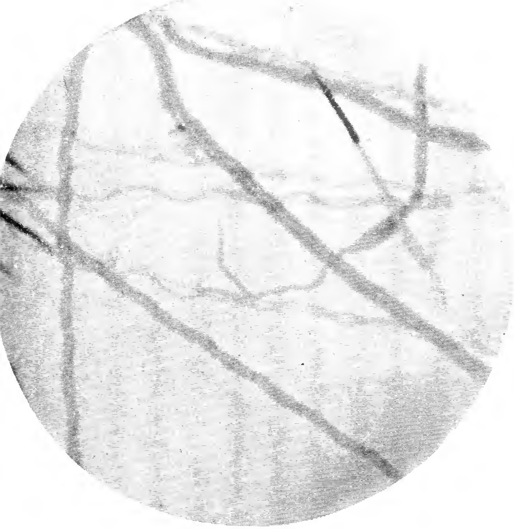


Fig. 2.

Fig. 4.

T. A. O'DONOHOE, *photomicrogr.*

SPERMATOZOA OF THE BLOW-FLY AND FLEA.

AN IMPROVED COMPOUND MICROSCOPE BY JAMES MANN.

By Edward M. Nelson, F.R.M.S.

(*Read October 24th*, 1911.)

This microscope, which supplies three steps in the evolution of the modern microscope, was kindly brought to my notice by Mr. T. Court.

The instrument is figured on a plate in a pamphlet* (dated 1751) which accompanies it. The microscope in the main is obviously a copy of J. Cuff's (1744),† the improvements consisting in the mirror and its attachment, and in making the instrument portable.

The first portable compound microscope was made by George Adams in 1746, and in this instrument we see Mann's device for adapting Adams's idea of portability to Cuff's microscope. Very probably this was the second portable compound microscope.

There are, however, other and more important improvements: (1) The mirror is plane and concave, thus predating that of

---

* Title: " A Description of the Compound (formerly called the Reflecting or Double) Microscope, with great improvements. London made and sold by James Mann, at the sign of Sir Isaac Newton's Head, and Two Pair of Golden Spectacles, near the west end of St. Paul's, 1751."

† *Journ. Q. M. C.*, Ser. 2, Vol. VII., p. 116, fig. 23 (1898).

François Watkins*; (2) the mirror is for the first time attached to the limb and not either to the box or to the foot; (3) the distance of the mirror from the stage can be varied, as there are two holes, one above the other about one inch apart, in the limb; and the mirror, to which a pin is fitted, can be attached to either of them.

The above improvements, of which these are the first examples, have remained to the present time. The limb is attached to the top of the box foot by a dovetail slide; when the microscope is packed in its box a plain plate of brass is placed in its stead to preserve the dovetail.

The bull's-eye is attached to the right-hand side of the stage instead of the front as in Cuff's.

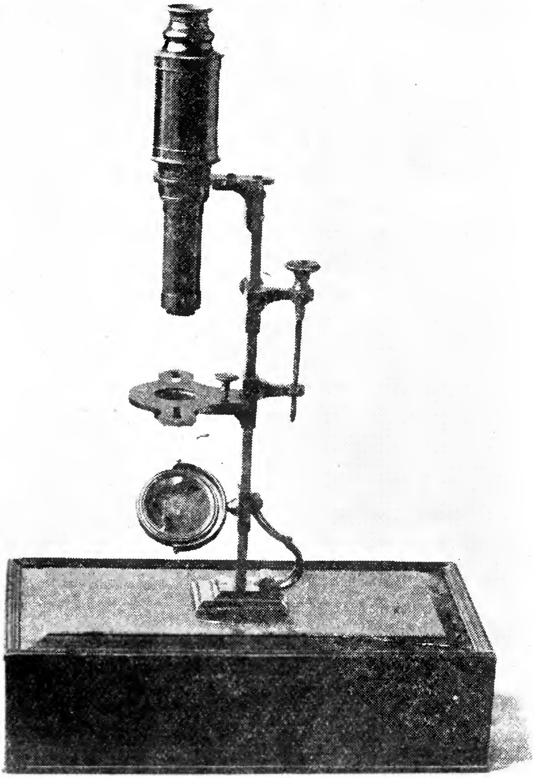
The figure in the pamphlet is a copy of Cuff's, for the ribbon on the fish-pan is wound in the same way and there are the same reflections in the various glasses; the microscope itself, with the exception of the details mentioned above, even in its ornamentation, is precisely similar to Cuff's.

There has always been a difficulty in dating microscopes of this period owing to the uncertainty of the date of Cuff's death or retirement from business. Here we have an authentic and dated copy of one of Cuff's microscopes in 1751. It is not conceivable that such a flagrant plagiarism would have been perpetrated. We know from Adams's illustrated catalogue that he was making all Cuff's models in 1771. We also have in Ellis's work on the Corallines (1755) a description of the aquatic microscope Cuff made for him. So it has been customary to fix the date of Cuff's retirement from business between the years 1755 and 1771. But obviously the publication of Ellis's work in 1755 does not imply that his microscope was made in that year;

---

* *Journ. R. M. Soc.*, 1908, p. 143, fig. 26.

on the contrary the probability is that it was made much earlier, and that Ellis had been working with it some years in the preparation of his book. Similarly Adams may have made Cuff's microscopes some time before the publication of his 1771 illustrated catalogue. The discovery of this dated microscope affords, therefore, strong evidence that Cuff must have given up business or died before 1751.



The name S. Johnson is engraved on the stage plate, and it is almost certain that this microscope was the property of the celebrated Dr. Johnson; but what he, with his defective eyesight, saw through it history does not inform us.

Mr. Court, some of whose beautiful instruments are to be seen at South Kensington, by bringing this microscope to the notice of the Club has enabled us to date correctly an important landmark in microscopical history.

NOTICES OF BOOKS.

Practical Photomicrography. By J. Edwin Barnard, F.R.M.S. $8\frac{3}{4} \times 6$ in., xii + 322 pages, with 79 illustrations and 10 plates. London, 1911. Edward Arnold. Price 15*s.* net.

The ability to write a book on the above subject nowadays implies a wide knowledge of three diverse subjects. The writer should be well acquainted with the finer side of mechanical engineering, he should be fully at home in the difficult subject of microscopic optics, and, lastly, chemistry, as required in photographic processes, should withhold no secret from him.

As one would naturally expect from the official position which Mr. Barnard so worthily holds, these three desiderata are amply fulfilled in his book *Practical Photomicrography.* The adjective in this case is no misnomer; "practical" the book is to the last degree.

In our mind, it has long been a subject worthy of discussion, revolutionary though it may seem, as to what extent the microscope should be discussed in a work on the above subject. In our experience, we have never met a photographer who purchased a microscope for the pleasure of photographing things at so many hundred diameters; on the other hand, photographic work for recording purposes eventually becomes a necessity to the microscopist, generally long after he has become familiar with the optical properties of his lenses and the adjustments of his instrument.

Mr. Barnard has evidently realised this point, consequently what we may irreverently call the "makers' catalogue" portion is all but missing from his book. In a like manner the pages of irritating mathematical formulae are excluded *in toto*—and rightly, as such are better obtained from works exclusively devoted to the subject.

For the larger and photographic portion of the book we must express our greatest admiration, and particularly as regards the chapter on "General Preliminary Preparations." No detail, however trivial, has escaped Mr. Barnard's attention. His insistence on cleanliness and order in the dark-room is a most admirable point and is, alas, one that is commonly neglected. His advocacy of a green safelight is another good point which should be adopted when possible. Only those who spend long hours in a dark-room illuminated in this manner know the incalculable relief afforded by this simple means.

We cannot agree with Mr. Barnard, however, in his advocacy of home-made light filters. This is work demanding the utmost scientific accuracy, as a rule far beyond the powers of the amateur, however willing. It is at the best a messy task, and generally costs more in the end than a filter prepared under scientific conditions.

In a later chapter the author deals with photographic processes. This is quite encyclopaedic in character; and bearing in mind the critical necessities of the work, we regret to find no mention of paraphenyelene diamine among the developers. In spite of the difficulties attending its use, there is a decided gain in resolution of fine detail which more than compensates for its disadvantages. We are bound to disagree with Mr. Barnard on the subject of contact printing with regard to lantern slides. We are most emphatically of opinion where absolute sharpness is necessary (as in a microscopical subject) that it is by far the better plan to make them through the camera.

The book is written throughout in the clearest and most attractive style. It reflects the greatest credit on Mr. Barnard, and should prove a useful aid to the photomicrographer for a very long time to come. Our greatest regret is that at the end of the book the publishers have seen fit to reproduce Mr. Barnard's fine examples by the collotype process. In a work published at this price we think that these should have taken the form of actual photographic prints from the original negatives; as it is, we cannot consider the results as published do the author's photographs justice.

A. C. B.

THE LIFE OF CRUSTACEA. By W. T. Calman, D.Sc. $7\frac{3}{4} \times 5$ in., xvi + 289 pages, 32 plates, and 85 figures in the text. London, 1911. Methuen & Co. Price 6*s*.

In this new work on the Crustacea Dr. Calman has given a most attractive account of this very important group of animals mainly from the point of view of their habits and adaptations to their surroundings. The general structure, classification and strange metamorphoses of Crustacea are indeed ably dealt with in three preliminary chapters, but the principal portion of the book is devoted to a review of the Crustacean communities characteristic of the sea shore, the ocean depths, the high seas, fresh-waters and the land, while three concluding chapters treat of Crustacean parasites and messmates, Crustacea in relation to man and the Crustacea of the past. As may readily be imagined, the description of the wonderfully varied forms included in the foregoing categories suggest numerous problems of much scientific and general interest, and it is an excellent feature of the book that these problems receive a good deal of attention.

With a book so crowded with interesting matter it is obviously impossible in a short notice to do more than refer somewhat arbitrarily to a few of the points touched upon. Thus, special attention may be called perhaps to the chapter on the floating Crustacea of the open sea in which we get much general information about the plankton and its relation to the higher marine animals such as the fishes and whales. The closeness of this relation is summed up in the striking phrase "all fish is diatom," the words being used in the same physiological sense as those in the biblical generalisation "all flesh is grass." It follows that the study of the plankton, a very large proportion of which consists of microscopic Crustacea, is of great practical importance as well as scientific interest.

Many examples of the extraordinary modifications of structure in pelagic Crustacea are given, and the exceeding transparency, brilliant coloration, and marked phosphorescence of certain species, also form subjects of special comment. In connection with the question of transparency, doubt is thrown on the idea that this is to be regarded as a protective adaptation because of the fact that some larger animals, such as the herring and Greenland whale, swallow the plankton wholesale. In support of the usual view it may be suggested, however, that the main struggle for existence with these plankton organisms is not between them and such creatures as fishes and whales, but between themselves, and that consequently transparency as such may be an extremely useful character. In any case it can hardly be claimed that the indiscriminate consumption of plankton Crustacea, etc., by fishes and whales furnishes an argument against protective adaptations among the former, as it is difficult to see what modifications, other than being absolutely poisonous perhaps, could protect the smaller against the larger creatures in such circumstances.

In the chapter on the fresh-water Crustacea the very puzzling but nevertheless very interesting problems of distribution come very much to the front. It is shown that, generally speaking, fresh-water Crustacea, in common with most other fresh-water organisms, have a remarkably wide distribution, some species even being cosmopolitan. On the other hand, some individual lakes such as Tanganyika and the Caspian have developed quite peculiar faunas of their own. The wide range of some species is probably easily accounted for by the fact that they produce special eggs, *e.g.* the "ephippial" eggs of the Cladocera, which can be dried and blown or carried about without injury. But other widely distributed species do not produce such eggs, and it may be that in these cases the adults themselves can survive long journeys. The recently discovered fact that certain species of *Cyclops* and *Canthocamptus* have the habit of surrounding themselves with a cocoon-like capsule of mud particles seems to throw a new light on the possibilities in this direction.

The two chapters specially mentioned above contain the bulk of the references to micro-Crustacea to be found in the book, but naturally there is also much of interest on the smaller forms in the section dealing with the Crustacea as parasites. Of these perhaps the most curious case alluded to is that of the Monstrillidæ, in which the animals are hatched as free-swimming nauplii, then become so absolutely parasitic within the body of a marine worm that each consists only of a little ovoid mass of cells, which, however, finally develops into a free-swimming adult, but minus all trace of appendages between the antennae and the first pair of feet!

Dr. Calman is to be congratulated on the appearance of this compact, up-to-date and beautifully illustrated "Life," and it is sincerely to be hoped that the book will find a wide circle of readers and do much to stir up further interest in a group of animals which has not yet received the amount of attention it deserves. In view of probable future editions two little suggestions may be permitted perhaps. A word so long and so widely used as "Entomostraca" should surely be mentioned somewhere, if only in a footnote, and such phrases as "slightly enlarged," "much reduced" etc., which occur under many of the figures, might usefully be replaced by the approximate number of times the object is magnified or reduced.

D. J. S.

BROWNIAN MOVEMENT AND MOLECULAR REALITY. By M. Jean Perrin. Translated by F. Soddy, M.A., F.R.S. $8\frac{1}{2} \times 5\frac{1}{2}$ in. 93 pages, with 7 figures. London, 1910. Taylor & Francis. Price, 3*s*.

It was in the year 1827 that the botanist, Robert Brown, first directed attention to the fact that small particles suspended in liquids were in a constant state of movement. Most microscopists are familiar with this "Brownian movement," as it is styled from its first observer, in the apical vacuoles of Desmids belonging to the genus *Closterium*. Under the above title we have a translation by Mr. F. Soddy of Prof. J. Perrin's memoir dealing with his experimental researches on the behaviour of small particles suspended in fluids and the bearing these results have upon the question of molecular reality. The experiments were made upon uniform emulsions of gamboge and of mastic, and by a process of fractional centrifuging Prof. Perrin was able to obtain emulsions in which the nearly equal granules suspended in the liquid varied in diameter in different experiments between one-tenth of a micron and one micron. From the data obtained during his experiments the author is able to show that the law of gases first enunciated by Avogadro, already extended by Van 't Hoff to dilute solutions, extends also to uniform emulsions. In other words, the suspended particles behave in all respects like the molecules of a perfect gas, their movements, visible under the microscope, being due to the molecular impact of the surrounding molecules. The "Brownian movement" thus offers us, on a different scale, the faithful picture of the movements possessed, for example, by the molecules of oxygen dissolved in the water of a lake, which, encountering one another only rarely, change their direction and speed by virtue of the impacts with the molecules of the solvent. We are much indebted to Mr. F. Soddy for putting this interesting memoir in an English dress.

RECENT ADDITIONS TO THE LIBRARY.

Calkins, G. N.
The Protozoa (Columbia University Biological Series) 1901

Crombie, James M.
A Monograph of Lichens found in Britain, Part 1 . 1894

Hanausek, T. F.
The Microscopy of Technical Products, translated by A. L. Winton, 1st Edition 1907

Jennings, H. S.
Behaviour of the Lower Organisms (Columbia University Biological Series) 1906

Lankester, Sir E. Ray.
A Treatise on Zoology. Part 1, Introduction and Protozoa.
Fascicle 1 1909
,, 2 1903

Matthews, J. Merritt.
The Textile Fibres, 2nd Edition 1908

Murray, James.
British Antarctic Expedition, 1907–9.
Vol. 1, Biology, Pts. 2, 3 and 5. 4° . . . 1910

Scott, D. H.
Studies in Fossil Botany, 2nd ed.
Vol. 1, Pteridophyta 1908
,, 2, Spermophyta 1909

Strasburger, E., Noll, F., Schenck, H., and Karsten, G.
A Textbook of Botany, 3rd English Edition, revised from 8th German Edition, by W. H. Lang . 1908

Strasburger, E.
Elementary Textbook of Practical Botany, translated by W. Hillhouse, New Edition 1911

West, G. S.
The British Freshwater Algae (Cambridge University Biological Series) 1904

Wilson, E. B.
The Cell in Development and Inheritance, 2nd Edition (Columbia University Biological Series) . . 1906

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the meeting of the Club held on March 28th, the President, Prof. E. A. Minchin, M.A., F.R.S., in the Chair, the minutes of the meeting held on February 28th were read and confirmed.

Messrs. E. K. Maxwell, B.A., and Charles Coleman were balloted for and duly elected members of the Club.

The list of donations to the Club was read and the thanks of the members were voted to the donors.

The Hon. Secretary regretted to have to announce the death, on March 1st, of Mr. W. M. Bywater, F.R.M.S., in his eighty-sixth year. Mr. Bywater was one of the founders of the Club, in 1865, and was the first secretary. The Hon. Secretary was requested to send a letter of condolence from the Club to Mr. Bywater's family.

It was mentioned that Mr. Bywater had quite recently presented the Club with a collection of photographic portraits of past Presidents of the Club. The album was laid upon the table for the inspection of members.

The Hon. Secretary also announced the death, on February 25th, of Mr. Staniforth Green, at the age of eighty-three years. Mr. Green was probably the originator of the now usual method of mounting insects in balsam without pressure, a paper explaining his procedure having been read before the Club in 1883.

The Hon. Secretary had also to announce the death of Mr. F. Hovenden, F.L.S., F.R.M.S., who had been a member of the Club since 1867.

Mr. A. C. Banfield exhibited and read a note on "A New Quartz Mercury-Vapour Lamp." He said that in the exercise of his business as a photographer it formed part of his work to examine and report upon practically every new form of illuminant that was placed upon the market. The new lamp, which is manufactured by the Brush Electrical Co., is certainly not placed on the market from the point of view of things microscopical; but as it has several points of great novelty which make it extremely useful for this purpose, it was thought to be of sufficient interest to show to the Club. The usual vapour lamp is arranged for running on a 200-volt circuit, and takes the form of a luminous cylinder about 7 ft. in length, giving a great total luminosity with a relatively low specific intensity, which renders it unsuitable for microscopical purposes, and particularly for photomicrography. In the new lamp the unwieldy length of nearly 7 ft. has dwindled to about 4 in., although the candle-power remains the same—about 3,000—and the gain in the specific intensity is so enormous as to render it eminently suitable for microscopic use. The secret of the great reduction in length lies in the use of fused quartz in the manufacture of the tube. Quartz is a peculiar mineral in many ways, one among which is that it is exceedingly hard; it requires a very high temperature to fuse it, it is transparent to the ultra-violet rays, and it has an exceedingly small coefficient of expansion. This, in practice, means that the quartz tube can be run at a temperature which would soften a glass tube, when the sides would immediately collapse through air pressure. The very small coefficient of expansion prevents any cracking of the tubes through heat, and it is stated that they could be thrown while red-hot into a bucket of water without any risk of fracture. The lamp requires a current of 3½ ampères. A 200-volt tube will accordingly burn nearly three-quarters of a unit in an hour. A word of caution is necessary with regard to the ultra-violet rays, in which this lamp is extremely rich. The radiation is so powerful that it will sterilise a Petri dish cultivation in less than a minute. It is the composition of the light itself which renders it so useful in microscopy. Used without a filter, the absence of red rays improves the performance of an indifferently corrected objective. The peculiar mercury spectrum gives a unique opportunity of easily obtaining strictly monochromatic light in large quantity, with a choice of several wave-lengths. There are six principal lines in the spectrum—two in the orange, one in the green, one in the blue and two in the violet. The green line λ 5461 is perhaps the most useful, and forms at present the most powerful source of monochromatic light available. Mr. Banfield suggested that it would be worth while for opticians to construct a special set of objectives in which perfect spherical correction only is aimed at. Such a lens corrected for λ 5461 would be of the greatest use in photography, and should be a cheap article, and possibly better than an apochromat, owing to its flatter field. Thanks were expressed to Messrs. Wratten & Wainwright, Ltd., for the loan of a set of special mercury-lamp monochromatic filters, and to Mr. H. F. Angus for the loan of several spectroscopes provided for the examination of the spectrum.

On the motion of the President a vote of thanks was passed to Mr. Banfield for his exhibit.

A paper on "Dark-ground Illumination," communicated by Mr. E. M. Nelson, F.R.M.S., was then read by the Hon. Secretary.

At Mr. Nelson's request, Mr. C. Lees Curties, F.R.M.S., exhibited a specimen of the lamp and condenser described. The action of the substage condenser when used for dark-ground illumination was very well shown. A glass cell containing a fluorescing solution was placed on the stage above the condenser, and the emergence of the oblique rays from the top lens and their passing upwards through the object and divergence outwards away from the front lens of the objective conveyed to members a very much better idea of "how it worked" than any number of repetitions of diagrams or explanations.

Mr. W. Traviss exhibited several objectives fitted with an iris immediately behind the back lens. The rotating collar actuating the iris was graduated to show the N.A. employed.

The Hon. Secretary (Mr. W. B. Stokes) expressed his appreciation of Mr. Nelson's paper, which gave instructions so badly needed. He then warned members of the possibility of reducing the aperture of the substage condenser in one direction if the proportion between the width of the source of light and the width of the back lens of the substage did not equal the proportion between the focal length of the bull's-eye and the distance of the latter from the substage condenser. He assumed that the image of the bull's-eye was focused upon the object. Neglect of the suggested equation only affected the centre of the field when the edge of a lamp flame was the light-source. To avoid too great a distance between bull's-eye and condenser, he suggested shortening the focal length of bull's-eyes, which might necessitate the use of fused silica for the latter when intended for use with a Nernst lamp.

The thanks of the Club were accorded to Mr. Nelson for his interesting paper, and to Mr. C. Lees Curties and Mr. Traviss for the apparatus exhibited.

Owing to the number of papers on the agenda and the lateness of the hour, a note on "Some New Diatomic Structure discovered with a New Zeiss Apochromat," communicated by Mr. A. A. C. Eliot Merlin, F.R.M.S., was taken as read.

Mr. A. M. Jones said that at a recent meeting of the Royal Photographic Society, Mr. Max Poser, of Messrs. Carl Zeiss's London house, had stated that the objective referred to by Mr. Merlin was not constructed to a new formula, but was a picked one of the old series.

Mr. James Murray, F.R.S.E., F.L.S., made some introductory remarks to a paper he had contributed on "Water-Bears, or Tardigrada." The first notice in English of water-bears was in 1834 by Pritchard, of specimens found by Powell in Regent's Park. There have been many changes in the names of water-bears. They have now even lost the name Tardigrada, as that is already appropriated by vertebrates. The present official name of the group is order Arctiscoida, family Xenomorphidae. Mr. Murray said that his paper was intended to supplement the one contributed in 1907. Since that time considerable progress had been made in the knowledge of water-bears. A great many species have been discovered, and several new genera have been described —most of which are marine. The new genera are *Tetrakentron*, Cuénot, 1892; *Halechiniscus*, Richters, 1908; *Batillipes*, Richters, 1909; and *Oreella*, Murray, 1910.

Water-bears must no longer be regarded as a group as cosmopolitan as are the Rotifers. Recent researches have shown that half the known species are restricted to one locality, and about three-quarters to one country, and only about a dozen species are really cosmopolitan.

The paper went on to describe at some length the relationships of the various genera, and concluded with a synopsis of the ten genera known, and the 120 at present admitted species. A bibliography is appended.

A cordial vote of thanks was unanimously voted to Mr. Murray for his paper.

Mr. M. Ainslie exhibited and described a "finder" for the microscope useful with powers up to about $\frac{1}{6}$ in. It would fit any microscope stage, and was intended to make a mark on the label. It consisted of a spindle fitting in the hole in the stage intended to carry the side-reflector. It was there clamped. It carried a hinged arm with a brass point 0·5 mm. thick, adjusted to be over the slide 1 in. to the left of the centre of the objective —that is, equal to the amount of movement usual with an ordinary mechanical stage. In use, when an object is observed which it is wished to record, the brass point is wetted with ink and put down on the label. It was simple in construction, and very simple and easy to use.

Mr. Inwards thought the use of metallic paper would be found an improvement upon the method of making the marks.

The Hon. Secretary thought he had seen a description of a somewhat similar pointer to that which had been mentioned.

Mr. Ainslie said the "Coon" finder, which fitted on the edge of the stage and made two marks, was the one referred to, but it would not be so rapid in action as the one he had described.

The President expressed the thanks of the club to Mr. Ainslie for his interesting exhibit, which he thought was likely to prove very useful to many of the members.

At the meeting of the Club held on April 25th, the President, Prof. E. A. Minchin, M.A., F.R.S., in the Chair, the minutes of the meeting held on March 28th were read and confirmed.

Messrs. B. J. Campling, A. J. Bowtell and E. A. Pinchin were balloted for and duly elected members of the Club.

The Hon. Secretary read a list of recent additions to the slide cabinet, among which were 22 slides of marine algae, mounted by the late Mr. Buffham, presented by Mr. A. Smith; 19 botanical preparations, mounted and presented by Mr. H. Gunnery, of York; 6 slides, botanical and polyzoa, presented by Mr. C. Sidwell (Hon. Curator). The thanks of the members were voted to the donors.

Dr. A. C. Coles, of Bournemouth, sent some preparations mounted in parolein, to show the value of that fluid as a mounting medium.* It seems to be practically impossible to obtain perfectly neutral Canada balsam. Even in the best samples a slight trace of acid remains, and this causes more or

---

* *Lancet*, April 1911; *Knowledge*, May 1911, p. 192.

less complete loss of colour in most stained preparations. Parolein is absolutely neutral, and, so far as is known at present, is entirely without action on any dyes. Further, it has a lower refractive index than Canada balsam—1·471—as against 1·530 of balsam in xylol. The following preparations, mounted in parolein, were exhibited under microscopes very kindly lent by Messrs. H. F. Angus and Co.: (1) Pernicious anaemia, Giemsa stain; (2) Spirochaete and *Bacillus fusiforme* of Vincent's angina; (3) *Spirachaeta pallida*; (4) Trypanosomes of Surra.

The President said he also had had bad experience of Canada balsam. In the case of a number of mounts of calcareous sponge spicules, in some the spicules had been completely dissolved away; in others, mounted as long ago as 1896, no change at all had taken place. Some samples of balsam become acid very rapidly; others, apparently, not at all. He had noticed similar trouble in haematoxylin-stained preparations. The action was first noticed at the edge of the cover-glass, and gradually spread inwards. But, again, in other preparations, similarly stained and mounted, there had been no fading at all, and, in certain instances, even a slight darkening. He was very pleased to hear of a new mounting medium of such promise.

The President said he also had to thank Messrs. Angus & Co. for the loan of the microscopes used to exhibit the preparations he had brought down to the meeting. He had for the last year been studying *Trypanosoma lewisi* in rat-fleas. He had had occasion to dissect many rat-fleas, and sometimes got out the organs very nicely. The salivary glands were very important from his own point of work, and one of the preparations exhibited was of the salivary glands of the rat-flea. The system has first a common opening in the proboscis, then a short tube branching in two, as a Y-piece, of thin calibre, and with quite smooth chitinous walls. The branches of the Y lead right and left inside the body, and the tube becomes slightly thicker, and looks something like trachea, but is more or less irregular. The irregularities are most apparent when the fresh preparation is examined in salt solution. The two branches run back through the thorax to the abdomen, and, branching again, end in little pouch-like bodies, which are very difficult to stain. Altogether, there are four salivary glands in the body of the rat-flea. The President said his first dissection of insects was of the tsetse fly, in Africa. Most insects have the salivary glands in the thorax; but the tsetse fly has them in the abdomen, similar to the rat-flea. The explanation is that the arrangement is an adaptation to the extremely muscular thorax, and every other organ is reduced in dimensions; and so, among other things noticeable, we find the salivary glands carried right back to the abdomen, with as small a duct as possible. It was curious that the only two kinds of insects he ever dissected should both have the salivary glands carried back to the abdomen. He had occasionally found in the fleas a cysticercoid, which was proved by actual experiment to be a larval stage of the tapeworm of the rat, *Hymenolepis diminuta.* The flea became infected during its larval stage. The flea larvae often feed on the faeces of the rat, and ingest the eggs at this stage. There is no doubt whatever that the life-cycle is completed by the rat catching and eating the fleas. The host of this intermediate stage was previously unknown. About 4 per cent. of the fleas examined were infected, and sometimes two or three cysticercoids were found in one specimen. Recently a second cysticercoid had been found. The first form had no hooks, but the second had a notable circle of hooks. Only two specimens had, so far, been found, and these were not yet positively identified, but were believed to be *Hymenolepis murina.*

The preparations exhibited were: (1) Cysticercoid of the rat-tapeworm, *Hymenolepis diminuta*, from the body-cavity of the rat-flea, *Ceratophyllus fasciatus*, with head invaginated; (2) the same, with head extended; (3) another species of cysticercoid, probably *H. murina*, also from the body-cavity of the rat-flea; (4) ventral nervous system of the flea, *C. fasciatus*; (5) salivary glands, and duct of the same.

Mr. D. J. Scourfield, F.Z.S., F.R.M.S., then read a paper on "The Use of the Centrifuge in Pond-life Work."

Mr. C. F. Rousselet said they were much indebted to Mr. Scourfield for explaining several difficulties not infrequently met with. If rotifers were kept for a few days, it was found that their stomachs became empty, and at the end of a week they were all dead. It would be very useful to know what kind of small organisms such creatures used as food, as we should then be able to supply it, and keep specimens alive for a longer time.

Mr. Gabb said the application of the principle of the centrifuge was due to Laval, who in 1885 invented what he called the lactorite for the purpose of milk separation; he believed it was the first instrument for the purpose of separating bodies of different densities.

The President said that thanks were due to Mr. Scourfield for drawing attention to this instrument. The centrifuge is very useful in many different kinds of work, and it often enormously shortens the time taken. Some time ago he had occasion to make a number of preparations from human faeces, from which it was desired to examine certain small amoebae therein contained. A small quantity, together with the first liquid, was placed in a tube and centrifuged, the liquid decanted off, the next liquid added, centrifuged, decanted off, and so on, down to xylol. Finally, the material was pipetted out, and mounted. It was a very useful and very rapid method of doing exactly the same as that with a piece of tissue, which could be held with forceps. *Trypanosoma gambiense* was first discovered in the cerebrospinal fluid by Castellani by the use of the centrifuge, and it was a discovery of immense importance. The centrifuge was a most useful adjunct to any laboratory for all kinds of work. It was most astonishing that even the most delicate forms were not injured by centrifuging. One could, of course, drive slower and for a longer time, and so get less chance of damaging these delicate organisms.

The thanks of the Club were unanimously voted to Mr. Scourfield for his paper. The Hon. Secretary said they had another paper on the agenda, by Mr. Soar, but in view of the absence of the author and the lateness of the hour this paper would be held over until their next meeting.

Among a number of preparations exhibited at the meeting may be mentioned: *Spirogyra orthospira*, Nag., by Mr. James Burton; organisms taken by tow-netting in the Faroe Channel with some especially fine specimens of *Globigerina bulloides*, pelagic type, showing the armament of spines, by Mr. A. Earland, F.R.M.S.; pupal condition of *Corethra plumicornis*, by Mr. S. C. Akehurst.

At the meeting of the Club held on May 23rd, Mr. E. J. Spitta, L.R.C.P., M.R.C.S., Vice-President, in the Chair, the minutes of the meeting held on April 25th were read and confirmed.

Messrs. Charles A. Bunnin and Cyril E. Pells were balloted for and duly elected members of the Club.

The list of donations to the Club was read and the thanks of the members were voted to the donors.

Dr. T. W. Butcher, of Blackpool, sent for exhibition a series of photomicrographs of *Amphipleura Lindheimeri*, taken under the following conditions: Homogeneous oil-immersion 2 mm. apochromat, compens. ocular ×6, tube-length 170 mm., initial magnifying power ×764, achromatic substage condenser, screens D and H of Wratten & Wainwright's "M" series, illuminant Liliput arc-lamps (8 amps.). Ordinary backed plates (225 H. and D.); developer, metol hydrokinone; exposure, 12 secs. Also three higher-power photographs taken as above, but with compens. ocular ×18. The photographs showed the diatom well resolved from end to end. In a covering note Dr. Butcher said the points were simply a straightforward example of direct-light illumination with the particulars given, and were more a demonstration of lens efficiency than of revealing structure.

Mr. C. L. Curties exhibited a series of slides mounted by Mr. Waddington illustrating the development of the trout from the ovum to fifteen weeks old.

The Chairman moved a vote of thanks to the preparer of these slides and also to Mr. Curties for exhibiting them—remarking that the exhibition was a unique one, and such as they would have little opportunity of seeing unless they were brought to their notice in this way.

Mr. C. D. Soar, F.L.S., F.R.M.S., read a paper on "The Work of the late Saville Kent on British Hydrachnids."

Mr. D. J. Scourfield congratulated Mr. Soar on having had the opportunity to see and use Saville Kent's work. It was very interesting to have an account of what Saville Kent had in mind to do, and how much material he had collected and partly examined. It was a great pity that Saville Kent was not able to complete this work.

Mr. C. F. Rousselet said that the probable cause was that Saville Kent was sent to Australia for a number of years to study coral reefs, and this, of course, took him away from the study of water-mites.

The thanks of the meeting were voted to Mr. Soar for his paper.

A paper contributed by Mr. E. M. Nelson, F.R.M.S., on "Methods of Illumination," was read by the Hon. Secretary (Mr. W. B. Stokes).

The thanks of the meeting were unanimously voted to Mr. Nelson for his communication.

Mr. T. A. O'Donohoe exhibited on the screen a number of photomicrographic lantern-slides: part of proboscis of blow-fly mounted without pressure, showing the ducts in their natural condition; a series of diatoms at moderate magnification; *Surirella gemma*, *P. formosum* and *C. asteromphalus* at × 2,000; and several different images of Podura scale at high magnifications. Mr. O'Donohoe also exhibited under the microscope the preparation of the proboscis of blow-fly without pressure, of which he showed photographs.

At the meeting of the Club held on June 27th, Mr. C. F. Rousselet, F.R.M.S., Vice-President, in the Chair, the minutes of the meeting held on May 23rd were read and confirmed.

Mr. L. C. Bennett was balloted for and duly elected a member of the Club.

The list of donations to the Club was read and the thanks of the members were voted to the donors. It was also announced that a donation of 19 slides—5 of Polycystinae, 9 of diatomaceous earth and 5 others—had been presented to the Cabinet by Dr. M. C. Cooke.

The Chairman said that Dr. M. C. Cooke was one of the founders of the Quekett Microscopical Club, and was its President during 1882 and 1883, but owing to his advanced age and increasing infirmity he had long been unable to attend any of the meetings, but still retained a lively interest in the welfare of the Club, although very few of his old colleagues now remained. It had been thought well in acknowledging his gift of slides that the members of the Club should be asked to pass a resolution that evening expressing not only their thanks for his donation, but also their high appreciation of the services he had rendered in the past, not only to the Club, but to science generally, by his numerous published works, and especially by his editorship of the earlier volumes of Hardwicke's *Science Gossip*. Dr. Cooke was now in his 87th year, but notwithstanding failing eyesight and enfeebled health he was still able to appreciate visits from old friends and to enjoy a chat with them about the days gone by. A cordial vote of thanks to Dr. Cooke for his donation and a resolution of appreciation and sympathy were then put to the meeting by the Chairman and carried with acclamation.

Mr. J. W. Ogilvy, F.R.M.S., for Messrs. Leitz, exhibited and described a recent invention of his firm for rendering visible particles in smoke or gases and in liquids. It was on the principle of the dark-ground condenser. Replying to a question by the chairman, Mr. Ogilvy said he did not think the size of smoke particles had yet been measured. Siedentopf had measured the size of particles in liquids.

The Hon. Secretary thought that the most interesting thing about this exhibit was the microscope under which it was shown, seeing that this approximated more nearly to the English pattern than anything he had yet seen made by any foreign maker.

Mr. Ogilvy said that this instrument had been made by Messrs. Leitz to his own instructions; the upper part was on the usual Leitz model, and it was fitted with their new fine adjustment, but the stage was not yet complete. Another similar instrument was being made, which would be still further improved, and would be so arranged that both long and short tube lengths could be employed to suit various objectives.

Messrs. Watson & Sons exhibited a series of seven preparations illustrating the development of the chick. The stages shown were at the following periods of incubation: 24, 32, 40, 48, 60, 72 and 96 hours. The embryos are suitably stained, and are mounted in deep cells. The slides are issued with a leaflet fully describing each stage. The same firm also exhibited a new form of dissecting compound microscope fitted with a Porro prism erector.

On the motion of the Chairman a vote of thanks was passed to Messrs. Leitz and Watson & Sons for their exhibits.

The Secretary said they would regret to hear that owing to his present serious condition Mr. Alpheus Smith had felt obliged to resign his position of Hon. Librarian, which he had held for so many years. Whilst expressing their regret at Mr. Smith's retirement he proposed that a hearty vote of thanks be given to Mr. Smith, with an expression of their sympathy on account of the accident which had incapacitated him for a time.

The Chairman said the Club had been very fortunate in having the services of Mr. Smith for so long a period, for he had been their librarian for nearly forty years, during which time he had done all the work by himself. He thought this was a unique instance, for he did not think there had been any previous case in which the Hon. Librarian of a scientific society had continued his work for so long a time. They were of course very sorry to lose his services, though at his advanced age this was rather to be expected; indeed, he had intended to resign at the end of the year, so that the accident had only anticipated this by a few months. The members would be glad to hear that Mr. Smith was going on well, and hoped to be about again shortly.

The vote of thanks and sympathy to Mr. Smith was then put to the meeting and unanimously carried.

Mr. A. Earland, F.R.M.S., read a paper communicated by Dr. E. Penard, of Geneva, on "Some Rhizopods from Sierra Leone."

A hearty vote of thanks to Dr. Penard for his paper was carried unanimously.

Mr. T. A. O'Donohoe read a paper "On the Spermatozoa of the Flea and the Blowfly," and illustrated the subject with a number of photographs thrown upon the screen.

The Chairman, in proposing a vote of thanks to Mr. O'Donohoe for his paper, said that though the subject was not one which appeared to have been studied by the members of the Club, he thought it was well to have their attention called to it.

Mr. E. M. Nelson's paper, "On the Effect of Normal and Abnormal Vision on the Power of the Microscope," was read by Mr. J. H. Pledge (Hon. Assistant Secretary).

The Chairman moved a vote of thanks to Mr. Nelson for his communication, which at that late hour it would not be possible to discuss.

The Hon. Secretary announced that the Committee had appointed Mr. Akehurst as Librarian and Mr. Caffyn as Assistant Librarian in place of Mr. Smith. He was sure the members of the Club would be glad to know that they had amongst them those who were willing to undertake duties which were more or less onerous, and constituted a tie upon their spare time.

THE PRESIDENT'S ADDRESS.

SPECULATIONS WITH REGARD TO THE SIMPLEST FORMS OF LIFE AND THEIR ORIGIN ON THE EARTH.

By Prof. E. A. Minchin, M.A., F.R.S.

(*Delivered February 27th*, 1912.)

Gentlemen,—

It is with no slight feeling of diffidence that I venture to discuss the subject which I have chosen for my address to-night, since there is perhaps no problem in the whole range of the natural sciences which appears to be so far beyond the possibility of final and definite solution as that of the origin of life. We must, indeed, "with no middle flight intend to soar" when we attempt to unveil so profound a mystery; we must fit our imagination with wings that can carry it across the profoundest abysses of space or the most immense periods of time. Scientific men are not agreed as to the probable length of time during which living beings have existed on this terrestrial globe of ours; but the lowest estimate is about a hundred million years, the highest about a thousand million. What can the human intellect pretend to know with any approach to certainty about events from which we are separated by so vast an interval of time? All that we can attempt is to discuss the conditions and limitations of the problem with the object of ascertaining what are its possible or probable solutions. I think I need not apologise for bringing the subject of the origin of life before this Club, since the progress, slight though it may be, that has been made towards a solution of the problem would have been impossible without the aid of the microscope.

Before I can approach the main problem, that of the origin of life, it is necessary to discuss first the nature of the living substance, and to gain, if possible, some notion of its simplest or most primitive form. For this purpose I shall be obliged to trouble you with a certain number of hard facts, some of them difficult and abstruse, others perhaps tedious from their familiarity, which I shall endeavour to deal with as briefly as possible.

In our experience of the natural world there is no sharper distinction to be drawn, with regard to the objects around us, than that between the living and the not-living, between animate and inanimate objects. This distinction is one which is forced upon us from our earliest years; we learn to discriminate between things with and things without life long before we are able to form any exact notion of the distinctive characteristics or properties of living beings. Our conception of life is based on the facts of experience, as that of a property possessed by some things, not by others, and easily lost by those which possess it. Further knowledge, even when based upon exact scientific studies, does not lessen in any way the fundamental distinction between living and lifeless objects. We obtain a clearer and more accurate notion of the characteristic properties of living things, and become able to state with more exactness what objects should be classed as animate or inanimate respectively. But with increase of knowledge the distinction becomes ever sharper, and the gap between the living and the not-living remains as the widest gulf separating any two categories of natural objects, with nothing to bridge it, no transition from the not-living to the living.

Even in the present state of scientific knowledge, it is scarcely possible to frame an exact definition of life in the abstract. It is better not to attempt it, but to inquire merely, what are the principal characteristics of living things, distinguishing them from those that are not living? The popular answer would be, movement, growth, specific form and reproduction according to kind, the offspring being like the parent; to these might be added the peculiar phenomena of sexual behaviour and sexual differentiation, and the possession by many if not all living things of faculties of the kind that we term mental or psychical. Some of these characteristics, however, cannot be applied rigorously for the purpose of distinguishing or identifying living things. Some things that undoubtedly have life do not exhibit movements perceptible to our unassisted senses; on the other hand, there is plenty of movement in lifeless things around us, in air and water. All living things grow, but so do some lifeless things under certain conditions—for example crystals, which also exhibit specific form. No lifeless things reproduce their kind, but reproduction may be regarded as discontinuous growth, and the offspring produced by a living body is not always similar to the parent, but sometimes very different from it, as in the well-known phenomena of alternation of generations. No inanimate object, however, exhibits sexual characteristics or psychical faculties.

Analysis of the properties of living things shows that their most distinctive characteristic is that which is known as metabolism, signifying that, however distinctive and apparently constant the form and characters of the living body may be, considered as a whole, its substance is undergoing incessant change. A living organism of any kind takes up substances from its environment and causes them to undergo chemical changes which result in their being built up into the substance of the living body itself. At the same time the living substance is also undergoing changes which result in its breaking down, with production, on the one hand, of simpler and more stable compounds than those which constitute the living substance, and, on the other hand, of energy in various forms, such as movement, heat, electrical changes, etc. Hence the principal manifestation of life is the exercise of two processes of change of substance; the one, termed anabolism, is the building up of the complex chemical substances composing the living body from simpler materials; the other, termed catabolism, is the breaking down of these complex bodies in order to generate energy. If the process of building up the body-substance is more active than that of breaking it down, as is usually the case, the result is growth or reproduction. The growth of a living body is therefore quite different from that of a not-living body, such as a crystal, which grows without chemical assimilation. A crystal of salt or sugar, for instance, can only grow in a liquid in which salt or sugar has been dissolved; but to grow a fern in a pot, it is not necessary to supply it with solution of fern, but only with water containing inorganic salts, air and light: then by means of the energy absorbed from the sun's rays the fern is able to absorb the simple substances that it obtains from its environment, to build them up into the complex fabric of its body, and to grow.

Whatever the form or specific characteristics of a living body, this fundamental vital property of metabolism remains its most distinctive peculiarity, the mark and sign of life. The metabolic process varies infinitely in detail in different cases, but remains throughout the same in principle: a chemical transmutation of substances to build up the complex material of the living body, and the breaking down again of the living substance to produce energy. The process of metabolism may be temporarily in abeyance, but complete inhibition and permanent cessation of metabolism means death; the body ceases to be living and becomes merely a mass of inert and lifeless substance. If a living body appears to us as a stable body, the fact is due solely to the limitations of our senses, which cannot take cognisance of the process of incessant change that is going on. Could we either magnify the substance of the living fabric, or increase the range of perception of our senses to such an extent that we could actually observe the chemical and physical changes taking place, then a living organism, however minute, would appear to us to hum like a factory or roar like a furnace. Chemical molecules are being taken in, broken up, their constituent atoms combined with others to build up huge molecules containing hundreds and thousands of atoms in more or less unstable union. These molecules in their turn are breaking down and smaller groups of atoms are being set free with explosive suddenness, producing heat, movement and other forms of energy.

If now we examine further into the composition of living bodies, we find them to contain universally a substance known as protoplasm, which presents itself as a viscid, slimy fluid, very rarely clear and transparent and then only in parts, but as a rule turbid and containing great numbers of granules and enclosures of various kinds. Some living bodies consist entirely of protoplasm: in others various structures and mechanisms are produced in and by the protoplasm, and by this means a very complex organisation may be produced. The general statement can be made, however, that living bodies consist either of protoplasm alone or of protoplasm combined with the products of its own vital activity. Protoplasm may, in short, be identified as the material basis of life.

When this substance, protoplasm, is examined further, it is found that from the chemical point of view it consists chiefly of substances known as proteins, the most complex chemical substances known. A familiar example of a protein is albumin, white of egg, but this is a protein of comparatively simple chemical structure; many other proteins are much more complicated in this respect, and contain a vast number of atoms of several kinds combined together, those of most common occurrence being carbon, oxygen, hydrogen, nitrogen, sulphur and phosphorus. Proteins are, in short, chemical compounds of such complex nature that at the present time they are quite beyond exact chemical analysis; it is impossible either to state exactly how they are built up out of their constituent atoms, or to make them artificially in the laboratory. Proteins are characteristic components of living bodies and can only be obtained from living bodies. The enormous chemical complexity of proteins admits of endless variations in them; apparently every species of organism has its own peculiar proteins, different from those of every other species.

There is a further difficulty with regard to the chemical composition of the living substance. The chemist can only deal with it when it is dead; he must begin his analysis by destroying the life. From the dead protoplasm a great number of different proteins are obtained; but it is impossible to state whether the proteins existed separately as such in the living body, or whether they were combined together into a far more complex substance. We cannot say at the present time whether the essential constituent of living matter is a single chemical substance or a mixture or combination of various chemical substances; though from the facts to be considered presently it seems more probable that the second alternative is the true one, and that there is no single chemical substance which could conceivably be isolated in a pure state and be exhibited as the living substance *par excellence.* In other words, the properties of living things are not to be regarded as inherent in one single chemical compound; from a strictly chemical standpoint there is no living substance.

Let us now consider briefly the physical and structural peculiarities of protoplasm. Taken as a whole, protoplasm is distinctly of a fluid nature; it may contain particles or structures of a firm consistence, but this does not prevent it being fluid in the aggregate. Some samples of protoplasm may be less fluid than others; some are very distinctly and obviously fluid, others may be stiffened to a degree that approaches very nearly to the solid condition, lying on the boundary between fluid and solid matter. The fluid nature of protoplasm is seen from a variety of facts that can be observed without difficulty; chief amongst these are its streaming and flowing movements and the tendency of masses of pure protoplasm to round themselves off and become spherical when they come to rest. Small masses of protoplasm like an amoeba assume a shapeless, irregular and changeable form when in movement; but when their activity ceases from any cause, they become spherical in form. In such organisms a definite, constant and characteristic body-form can be maintained only by the formation of firm structures which act like a primitive type of supporting skeleton, and which have the form either of internal rods or bars or of an external envelope like a skin. A further indication of the fluid nature of protoplasm is seen in the fact that drops of watery fluid, so-called vacuoles, suspended in the protoplasm, tend always to have a spherical form unless there is something to prevent this tendency.

The minute structure and physical nature of protoplasm is a disputed subject which it is not necessary for me to discuss in detail. Any one who has looked at an amoeba under a microscope of even moderate magnifying power knows that its body consists of a fluid ground-substance or *matrix* in which numerous *granules* are imbedded. As regards first of all this matrix, the views of experts are at variance; some consider it to be a homogeneous colloid fluid, but the majority of investigators hold that it consists of two parts, a delicate framework and a watery cell-sap. From the fluid condition of the protoplasm as a whole it follows that both framework and cell-sap must be fluid; they must then be regarded as two fluids which will not mix with one another. The framework is more viscid, and probably consists of albuminous substance; the cell-sap is more fluid, and appears to consist of water containing salts and substances of various kinds in solution.

It is to the granules that I must direct your attention more particularly. In any sample of protoplasm there are a great many different kinds of granules, as shown by their reactions to chemical reagents and stains. Many of the granules undoubtedly represent stages in the process of metabolism described above; that is to say, they are substances which are either on their way to be built up into the complex material of the living body, or substances which have come into existence by the breaking down of the living matter, and which will be eliminated eventually from it; they may be compared generally either to the fuel or the ashes of a fire. Such granules may be classed generally as metaplastic bodies—that is to say, as bodies which are not, strictly speaking, a part of the living protoplasm itself.

In addition, however, to granules of temporary metaplastic nature, there are certain other granules which appear to be of the greatest importance in the economy of the living substance, since they are of constant and universal occurrence in living organisms of all kinds—namely, the peculiar grains known as *chromatin*, so called on account of their property of taking up certain colouring matters, a peculiarity by which they are generally recognised. In organisms of the most simple type the chromatin-grains are distributed usually throughout the whole protoplasmic body, or the greater part of it; but in the majority of cases they are gathered together at one point, or more than one, to form a structure termed the *nucleus*—that is to say, the kernel, as it were, of a certain mass or lump of the living substance, which is then commonly termed a *cell*. The nucleus varies greatly in structure in different cases, but consists always of a collection of chromatin-grains combined with various accessory substances and structures which may be termed collectively achromatin. The chromatin-grains are the essential element of the nucleus, which never contains any metaplastic bodies of any sort.

When a true nucleus is present, the protoplasm outside it, constituting the cell-body, is commonly termed the *cytoplasm*; it may contain extranuclear grains of chromatin, so-called chromidia, or may be quite free from them. There is no essential difference, however, between the cytoplasm of a nucleated organism and the body-substance in those organisms in which the chromatin-grains are scattered through the protoplasmic body without being concentrated and organised into a nucleus; we may therefore use the word "cytoplasm" to designate the protoplasmic ground-substance or matrix apart from the chromatin-grains, irrespective of whether a definite nucleus exists or not. It is necessary to be clear about the meaning of the terms used, in order to avoid confusion of thought, and in the present case some writers use the word "protoplasm" as synonymous with cytoplasm—that is to say, to denote the ground-substance of the living matter in contradistinction to the nucleus or chromatin. I think it is best to use the term "protoplasm" for the living substance as a whole, regarding it as composed of two principal parts—namely, the cytoplasmic matrix and the chromatin-grains or nucleus, which, as universal and permanent constituents, are to be distinguished from temporary products of vital activity such as the metaplastic grains.

I must now enter into some further details with regard to the chromatin-grains. The usual test for chromatin is its staining properties, but this is, in reality, a very inadequate method of identification, for two reasons. In the first place, there may be present in the protoplasm formed masses of substances of various kinds which are not chromatin, but which may stain more intensely than the true chromatin, even with the so-called nuclear stains. In the second place, true chromatin often reacts very differently towards the same stain in different cases. A particular method of staining will colour the chromatin of one organism very deeply, that of another not at all. There is no dye known which can be relied upon to stain chromatin always, or which will stain nothing but chromatin in the protoplasm.

From the chemical point of view, all that can be said of chromatin is that it appears to consist of, or to contain proteins more complex than any part of the living substance; the so-called nucleo-proteins, characterised chiefly by being rich in phosphorus-compounds. The infinite variability of the proteins, already mentioned, is seen especially in the case of chromatin. It is highly probable that no two samples of chromatin are ever perfectly similar—a statement which applies not only to organisms of different species, but even to different individuals of the same species.

Chromatin, therefore, is not to be regarded as a substance which can be characterised or defined by chemico-physical reactions or properties. It would perhaps be better to speak of chromatins, or of the chromatin-class of substances, than to use the word "chromatin" in a manner that might convey the idea that a definite chemical compound was meant by it. The conception of chromatin is founded essentially upon its biological properties; it must be recognised and identified by its relation to the vital activities and life-history, as a whole, of the organism. There are many data both of observation and experiment which indicate that the chromatin-grains are of primary importance in the life and vital processes of organisms of all kinds. In the first place, the chromatin-grains appear to be invariably present in every living organism, and there are some organisms which consist of little or nothing but chromatin. When a cell or a simple living organism reproduces itself by the ordinary method—that is to say, by dividing into two or more daughter-individuals—the chromatin-grains divide also and are distributed amongst the offspring. In many cells the nucleus divides by a very elaborate mechanism, termed karyokinesis or mitosis, which ensures that of the two daughter-nuclei produced, each obtains one of the two daughter-grains of chromatin resulting from the division of each grain of chromatin that was contained originally in the nucleus of the parent-cell. And note this most remarkable fact of all : the sexual process, that great mystery of living matter, consists essentially, in all cases without exception, in plants and animals alike, of union of nuclei or chromatin from two distinct organisms. In the whole series, from man to sea-anemones and Protozoa, what are termed commonly affairs of the heart are in reality affairs of the chromatin-substance. The observed facts of fertilisation and development have led to the belief, I might almost say the conviction, in the minds of many naturalists that the chromatin-grains determine the characters of the offspring and are the bearers of hereditary tendencies and properties. Finally it should be mentioned that the special physiological function of the nucleus in the ordinary life of the cell appears to be that of producing the peculiar substances known as ferments or enzymes, substances which more than any others are characteristic of living bodies and of vital activities.

Equally remarkable are the results obtained by experiment. If unicellular organisms are cut into smaller parts, it is found that any part which does not contain the nucleus or a part of the nucleus may continue living for a short time, but dies sooner or later, and is incapable of feeding or growing and consequently cannot regenerate the lost parts of the organism. A portion of the protoplasm that contains no nucleus may exhibit for a time a certain amount of movement, and may continue to digest food-particles of which the digestion was begun before it was cut off from the nucleus, but it cannot initiate digestion, nor can it ingest food. Many Protozoa, such as Foraminifera, have shells of complicated structure, and if the shell be damaged the animal repairs the injury; but if its nucleus be removed the power of repairing injuries is lost. On the other hand, if a fragment cut off from a living organism contains the nucleus, or even a portion of the nucleus in some cases, it is able to continue living in a suitable environment, to feed, grow and finally regenerate the entire organism.

From the data obtained from experiment and observation alike, it is clear that the chromatin-substance is of the greatest importance in the life of the organism. Without it the cytoplasm cannot continue to live and cannot initiate the most characteristic activities of the living substance; the processes of assimilation and growth, reproduction and sex, all are dependent alike on the presence of chromatin in the protoplasm and cannot take place without it. Speaking for myself, I believe that it is the chromatin-substance which represents the primary living matter, the true material basis of life, and that the cytoplasm is of secondary importance in this respect.

The objection will doubtless be raised to the view that I have expressed, that, in the case of a unicellular organism, such as an amoeba or a ciliate infusorian, the nucleus isolated from the cytoplasm cannot live by itself and cannot regenerate the body unless a certain amount of cytoplasm be associated with it. This fact becomes perfectly intelligible, however, when we reflect that many organisms in Nature are so adapted and attuned, so to speak, to a particular mode of life that they cannot live except in certain conditions of environment, or unless supplied with special food. It would therefore be in no way remarkable if a nucleus, living always in a particular cytoplasmic environment, were unable to continue living when removed from its natural surroundings. The fact would not, in my opinion, disprove my contention that the nucleus—that is to say, the chromatin—is the primary living substance, any more than the fact that a fish cannot live out of water would be a proof that the water was living as well as the fish.

The most convincing proof, to my mind, that the chromatin is the primary living substance, is that many organisms appear to consist mainly, if not entirely, of chromatin alone, as for example some bacteria and spirochaetes, and above all the organisms known as Chlamydozoa. I must at this point say a few words about these Chlamydozoa, since they have been discovered or invented very recently—so recently that their very existence is not yet beyond a doubt, and they are not as yet very familiar even to the scientific public.

An acquaintance with the Chlamydozoa has gradually been forced upon scientific and medical investigators on account of the connection which some species of these organisms have with certain very well-known diseases of men and animals—diseases of which the true nature and cause have long been very problematical. Such, in the first place, are small-pox and vaccinia, trachoma and molluscum contagiosum in human beings, and in birds, epithelioma contagiosum and diphtheria. Other diseases possibly attributable to Chlamydozoa are hydrophobia, scarlet fever, measles, foot-and-mouth disease of animals, possibly also distemper, and the silk-worm disease known in Germany as "Gelbsucht." In all these cases the specific virus, different in its properties in each instance, has certain common peculiarities; the pathogenic organism, whatever it may be, is a "filter-passer"—that is to say, it can pass through ordinary bacterial filters without losing its virulence, and it produces characteristic reaction-products or cell-inclusions in the cells of the tissues which it attacks.

As an example of a chlamydozoal organism, I may describe briefly the life-history of the small-pox organism as it is stated by Hartmann, Prowazek and others to take place.* The infection begins with numerous "elementary corpuscles," minute grains barely visible, which can pass through the bacterial filters, and which occur both between and within the cells of the body. Within the cells the elementary corpuscles grow slightly larger, becoming the so-called "initial bodies." Their presence within the infected cell stimulates an abnormal growth of the cell-nucleus, which throws out nucleolar substance into the cytoplasm of the cell. The parasites become enclosed in this nucleolar substance as in an envelope or mantle, hence the name Chlamydozoa. The mantle with the contained parasites forms a characteristic

---

* See especially Hartmann, *Centralbl. Bakt. Parasitenkunde* (I. Abt., Ref.) xlvii., Beiheft, p. 94; Prowazek, *Handbuch der Pathogenen Protozoen* II. (Leipzig, J. A. Barth, 1911); Prowazek & Aragao, "Variola-Untersuchungen," *Mem. Inst. Oswaldo Cruz* I. pp. 147–158, pls. vii., viii., 2 text-figs.

cell-enclosure known in the case of small-pox and vaccinia as a Guarnieri's body, from its discoverer, who regarded it as the true parasite and named it *Cytoryctes*; according to the most recent investigations, however, the Guarnieri's bodies, and similar bodies in other diseases, are merely extrusions from the nucleus enveloping the true parasites—that is to say, the Chlamydozoa. Finally the Guarnieri's body breaks up, the cell becomes full of initial corpuscles which divide up into numerous elementary corpuscles, and the cycle is complete.

In all this cycle of development the Chlamydozoa multiply actively by simple division into two, and in this process of division there are some noteworthy features. The minute organism is not constricted simply into two, like a bacterium, but becomes dumb-bell-shaped, the two daughter-individuals as they separate being connected by a thread which is drawn out until it snaps. The division recalls that of a centrosome in an ordinary cell. I interpret this to mean that the minute body of a Chlamydozoon is not limited by a membrane like that of a bacterium, but is naked and of a fluid nature; consequently, when division takes place, the viscous body is drawn out in the manner seen and described.

Thus to sum up briefly the characteristics of the Chlamydozoa: they are organisms so minute as to be barely visible, in some cases, perhaps, quite invisible, with the highest powers of the microscope, and to be able to pass through filters which bacteria cannot pass. When seen, they present themselves simply as tiny specks of chromatin, in which no structure can be made out, and their mode of division indicates a structure simpler than that of bacteria, in that at least a membrane enclosing the body appears to be lacking. In all cases known at present they occur as parasites of cells in which they produce characteristic secondary growths or extrusions from the nucleus; although first known as causing diseases of man and the higher animals, they are now stated to occur also as parasites of Protozoa—for example, of *Amoeba* and *Paramecium*—and quite recently the opinion has been expressed that the elusive, and perhaps altogether mythical, cancer-parasite is to be referred to the Chlamydozoa.* To these various characteristics it should be added that

---

* Awerinzew, S., "Zur Frage über die Krebsgeschwülste," *Centralbl. Bakt. Parasitenkunde* (Abt. I.), lvi. pp. 506–508, 3 text-figs.

Chlamydozoa are difficult, if not impossible, to cultivate on the ordinary bacterial culture-media.

Returning now after this digression to the general problem, it may be said that the more minute a living body, the more it appears to be stripped, as it were, of all cytoplasmic elements and to be reduced finally to chromatin alone. It is, of course, impossible to analyse accurately the structure of the minutest organisms, and statements with regard to them must be made with the utmost caution in the present state of knowledge; but it can at least be asserted that while many organisms are known which consist mainly, if not entirely, of chromatin, there are none known which consist solely of cytoplasm, and in which the chromatin is entirely absent.

The conclusion which I, personally, draw from the facts which have been summarised briefly with regard to the living substance is that the primary living substance, the *primum vivens*, is chromatin; and from that I draw the further conclusion that the simplest and earliest forms of life were minute particles of chromatin, without other structural accessories, but nevertheless capable of the essential and characteristic activities of living things—that is to say, of assimilation, growth and reproduction by fission. The first steps in the evolution of more complicated forms of life were that these simple chromatin-particles formed other structures around themselves, at first probably in the form of simple protective envelopes, within which the cytoplasmic matrix was gradually developed, until the body was large enough to contain more than one chromatin-grain. This stage of structural complication is practically that seen in bacteria, speaking generally. With further increase of the cytoplasm, proceeding parallel with the concentration of the chromatin into a definite nucleus, the cellular type of organisation is produced, the starting-point for the evolution not only of the vast array of unicellular organisms, but also of all the ordinary animals and plants.

Now I would not have any of you go away with the impression that my views with regard to the chromatin-particles represent orthodox scientific doctrine. On the contrary, I believe that most biologists at the present day would reject my theory most emphatically and would consider me a heretic of the deepest dye for putting forward such suggestions. In conversation, at least, I have never found any one in the slightest degree inclined to fall in with my views. One objection, which has been put before me by my friend Dr. Chalmers Mitchell, is that in the evolution of the living substance the chemically-simpler may reasonably be supposed to have preceded the chemically-complex, and that if chromatin is more complex than cytoplasm in its chemical constitution, it is probable that cytoplasm was an earlier stage of evolution. Now, admitting, for the sake of argument, that the primary living substance has been evolved from chemically-simpler substances through a series of compounds in an ascending scale of chemical complexity, the question at once arises, at what point in the series was a substance produced which could be termed living? At the bottom of the scale are substances which no one could consider living, such as water, carbon dioxide and inorganic mineral salts; at the top are the complex proteins of the living substance. Are the properties of living matter the result of a continuous physico-chemical evolution from the properties of simple inorganic compounds? Or is life, as we know it, inseparable from a certain degree of chemical complexity, and if so at what point in the series did it come in? These are questions which no one can answer conclusively; all that we can say is that we know of no life that is not associated with chemical substances of the utmost complexity. And we may add further that it is by no means certain that life has been produced by a process of chemical evolution from inorganic to organic; a matter upon which I shall have more to say presently.

The current and orthodox biological view with regard to the primary form of the living substance and of living beings generally is what I may term the cytoplasmic theory, to distinguish it from mine, which I will call the chromatinic theory. According to this view, the cytoplasm is regarded as the primary living substance *par excellence*, of which chromatin is merely a product. The earliest living things were supposed to be formless masses of cytoplasm without a nucleus, Haeckel's Monera. Many naturalists seem to have regarded these hypothetical primitive organisms as by no means minute, not even what we should consider small. Most of us remember, I think, the unfortunate *Bathybius*, which was supposed to consist of primordial protoplasm carpeting square miles of the ocean bed, but which turned out to be a precipitate of calcium sulphate produced by adding alcohol to sea water. Quite apart from a trivial error of this kind, however, we may safely assert, I think, that the Monera, in the true sense of the word, do not exist. There are certainly organisms in which the chromatin-substance is not organised into a definite nucleus, meaning thereby a body of a certain degree of complexity of structure and co-ordination of parts; but we know of no organisms in which the chromatin-substance is absent altogether. The impression which I derive, rightly or wrongly, from the study of organisms of a simple type of body-structure is that those with abundant cytoplasm, such as amoebae, are far from representing the most primitive type of living beings, speaking generally. Comparison of different forms of life, so far as I am acquainted with them, seems to me to indicate as the most primitive type not a relatively large cytoplasmic organism, but an extremely minute body, a tiny speck of chromatin.

Having now enunciated my views, or perhaps I should say confessed my heresies, with regard to the primary form of life, I will now proceed to discuss its possible origin. I need hardly point out that this is a matter in which it is absolutely impossible to arrive at any certain conclusion. Our data are far too limited in every direction. All that is possible is to indicate the limitations of the problem, to put forward and discuss possible solutions of it, and to consider which of the solutions has, in the present state of our knowledge, the greatest degree of probability. Do not let us forget that a future generation, with increased knowledge and a wider outlook, will probably make merry over our efforts to solve an insoluble problem, just as we are apt to do over the speculations of our forefathers.

At the beginning of this discussion I may lay down two propositions which may serve to confine our speculations and theories within definite limits.

Proposition I.—Life does not originate on our globe at the present time.

This is the well-known problem of spontaneous generation, of biogenesis and abiogenesis. It is a negative proposition, and therefore one which can only be rendered highly probable but can never be proved, speaking from a strictly logical point of view, since a single instance of life originating *de novo* and not from pre-existing life would at once upset the generalisation. The evidence for the truth of the proposition may be summarised briefly as follows: On the one hand, it has often been asserted that life can originate *de novo*, but in every case the assertion, when critically examined, has proved to be baseless. On the other hand, the experience of many hundreds, even thousands, of investigators, working daily in bacteriological and other laboratories, affords a vast amount of accumulated support for the following statement: When a suitable culture-medium, natural or artificial, which has been previously sterilised, is planted, under proper precautions, with a particular species of organism, that species, and no other, develops in the culture. There is, in fact, such an enormous mass of evidence favouring the belief that an individual organism of any kind whatsoever is the offspring of a parent or parents similar in kind to itself, that the burden of proof rests on those who put forward statements to the contrary. Until, therefore, it has been clearly proved in a single instance that new life can come into being without having arisen from pre-existing life, we are fully justified in assuming that it cannot do so.

Proposition II.—There must have been a period when life did not exist on this earth.

This proposition follows inevitably from a consideration, first, of what is known positively with regard to living bodies; secondly, of the deductions of astronomers and others with regard to the past history of our planet. In the first place, all living things—at least, all those known to us—are extremely sensitive in regard to even moderately high temperatures. Some bacterial spores can survive being boiled in water for a short time, or require a temperature slightly above the boiling-point of water to kill them; but most living beings succumb at a temperature much lower than this, and there is certainly no form of life known to us which would not be destroyed instantly at a low red heat. Yet astronomers assure us that there was a time when our terrestrial globe was incandescent, and it seems as certain as anything can be that no life could have existed on the earth at that epoch.

Taking these two propositions together, that life does not now originate *de novo*, and that there was an epoch in which it could not have existed on the earth, it follows that there must have been some period of past time in which the teeming life of our planet first made its appearance—probably in some simple and primitive form that has given rise by a process of gradual evolution and differentiation to the immense variety of form and diversity of character which we see in living things at the present time, and which we know also, from the evidence of palaeontology, to have existed through many past ages of the world's history. To put it in one sentence, life on our earth must have had a beginning. If that be admitted, there are then two possibilities—the first that the life known to us originated on the earth itself, the second that it was introduced in some way to our planet from without.

It has been, I think I may say, the view held by the majority of naturalists that terrestrial life originated on the earth itself at an epoch when the earth was cooled down sufficiently to admit the possibility of living things existing on it. This view has been put forward by Sir Ray Lankester. I cannot do better than quote his exact words, as follows:

"A very interesting and difficult subject of speculation . . . is the nature of the first protoplasm which was evolved from not-living matter on the earth's surface. . . . A conceivable state of things is that a vast amount of albuminoids and other such compounds had been brought into existence by those processes which culminated in the development of the first protoplasm, and it seems therefore likely enough that the first protoplasm fed upon these antecedent steps in its own evolution just as animals feed on organic compounds at the present day, more especially as the large creeping plasmodia of some Mycetozoa feed on vegetable refuse. . . . At subsequent stages in the history of this archaic matter chlorophyll was evolved and the power of taking carbon from carbonic acid. The 'green' plants were rendered possible by the evolution of chlorophyll, but through what ancestral forms they took origin . . . it is difficult even to guess" (*Encyclopaedia Britannica*, 9th edition, art. "Protozoa").

If we try to realise in imagination the speculations conveyed in this passage, we may suppose that there was a period when the earth, though far hotter than at present, had cooled down to a certain temperature, sufficiently low for the formation of a firm though thin crust, and to permit of precipitation of water-vapour upon it. The thin crust of the earth was probably continually shrinking, cracking, upheaving, and allowing molten masses to escape from its interior on to the surface; such upheavals, in fact, as we see at the present time on a vastly smaller scale in volcanic eruptions. These cataclysms would cause rapid and explosive evaporations of enormous quantities of water, which would condense again when and where conditions permitted of its doing so. It is conceivable that the sudden and extremely violent changes of temperature, and the accompanying electrical disturbances, which must have been on a scale exceeding anything with which we are acquainted, would favour chemical decompositions and recombinations to an extent of which we can form no conception in the comparatively peaceful times in which we live; and that in the vast laboratory of Nature there might have been a synthesis and formation of chemical compounds, organic as well as inorganic, such as takes place nowhere in Nature at the present time, such as our chemists have not yet learnt to imitate, or perhaps have not the means of imitating. It is then further conceivable that this period of chaos, of storm and stress on a gigantic scale, might have been the womb of life; that is to say, that by a process of chemical synthesis in Nature, organic compounds might have been formed of ever-increasing complexity, until finally a pitch was reached when a form of matter was evolved possessing those properties and activities which we term vital. Thus might have come into existence the first protoplasm, surrounded by the material for its peculiar property of assimilation, in the shape of various organic compounds of slightly less complexity than itself.

Let us now examine this theory and its consequences a little more closely. In the first place, I need hardly say that we have no means of forming an exact notion of the condition of the earth at that period, nor whether the state of things that I have attempted to reconstruct in imagination would permit of such chemical synthesis as the theory requires. This is a point upon which chemists must pronounce; the naturalist as such cannot attempt to do so.

Turning next to the consequences of the theory, it is to be remarked in the first place that it assumes a chemical evolution of living matter from simple to complex. Consequently the more complex components of a living body, such as the chromatin, would be a later product of evolution than the simpler cytoplasmic elements. The Lankesterian theory of the origin of life would, therefore, favour what I have just termed the cytoplasmic theory of living matter rather than the chromatinic theory. The primitive living matter would be the cytoplasm;

the chromatin would represent one of the many elaborations of the living protoplasm to subserve certain functions. But the theory leads also to a conclusion of the most fundamental philosophical importance. If living matter, with all its remarkable properties and attributes, has arisen by a process of chemical evolution from simple inorganic compounds, then it follows that the properties of living matter differ only in degree, and not in kind, from those of not-living matter. In other words, such an origin of life would undermine and explode the whole basis of the vitalistic conception of life; that is to say, the view that the properties of living things are of a fundamentally different order from those of lifeless things, and that the living is not to be explained or interpreted finally by the physico-chemical properties of the not-living.

Returning now to our primitive protoplasm, surrounded by abundant organic matter for food, let us try to imagine its further history. Our knowledge of living things at the present time would lead us to suppose that the primitive organism would feed and assimilate very actively, growing rapidly in consequence, and then dividing up into smaller masses again; and further, that it would soon tend to become differentiated into various forms under the influence of different environments in different places. The conditions under which it came into being might continue for many ages, generating fresh supplies of food in the shape of organic compounds synthesised in Nature, but in all probability the supply would fall off gradually, since at the present day organic matter does not appear to be synthesised in Nature apart from living things, at least not to any very great extent; such organic matter as is found free in Nature at the present time is probably derived chiefly, if not entirely, from the death and decay of living organisms, or from their excretions. Consequently, our primitive protoplasmic organisms would have to find some new means of getting their livelihood. Some doubtless developed at an early period the animal method of preying upon one another. Fortunately, however, for the continuance of life on the globe, others developed special means and mechanisms for building up their substance by assimilating simple inorganic compounds. There were doubtless many methods of such assimilation, since among bacteria at the present time we find the utmost diversity in the methods of utilising simpler compounds for their growth.

One method, however, judging by its results, seems to have been much more successful, to have paid better, so to speak, than any other—the method, namely, whereby the living substance produced a pigment or class of pigments, sometimes yellow, red, or brown, but most usually green, termed chlorophyll, by means of which it is able to utilise the sun's energy in order to decompose carbon dioxide, and to build up the carbon, together with elements derived from water and inorganic salts in solution, to form the living substance. The organisms which invented, so to speak, this mode of life, flourished exceedingly, and gave rise in process of time and evolution to the entire vegetable kingdom, thereby permitting the evolution of the animal kingdom, depending directly or indirectly for its sustenance upon plants.

If any organisms exist at the present day which represent the original type of living being in its primitive form, unchanged through the ages, it is scarcely possible that they could still exist free in Nature, since they would require an abundant supply of organic nutriment, more abundant, probably, than would be found occurring in Nature. It is probable, therefore, that such organisms would have to be sought among parasitic or saprophytic organisms; that is to say, obtaining their supply of organic matter either from a living body or from one that has lost its life recently.

In contrast with the view that life originated on the earth itself, the suggestion has often been made that the first living things, or the germs of life in some form, were brought by some means to our earth from without. I will not attempt to review or discuss the many theories of this kind that have been propounded; I will confine myself to giving an account of the latest in the field—that, namely, of the famous chemist, Professor Svante Arrhenius,* who has put forward a hypothesis based on grand and wonderful conceptions. His theory starts with the notion that the beginning of life is coeval with that of our universe; that is to say, that "life must always have been in existence, however far back we may carry our thoughts," and that "life itself is eternal, like matter and like energy," so far as our minds can form a conception of eternity. With regard to this assumption, however, it must be pointed out that matter and energy

---

* *Worlds in the Making* and *The Life of the Universe.* (Harper & Brothers, London and New York.)

are indestructible, and only their form can be changed; while life, as we all know, can be completely destroyed, without passing into any other condition from which it can be resuscitated in its ordinary form.

Arrhenius believes that the life which populates our globe came to it from other inhabited worlds, the means of transport being the so-called radiation-pressure. It has been established by physicists that minute particles of matter below a certain size can be propelled through infinite space by the pressure of rays of light, heat, and all kinds of radiations, and could travel in this way from planet to planet or from star to star. In this way living organisms of a certain degree of minuteness could be disseminated all over the universe and could settle wherever the conditions were favourable. Intensely heated, incandescent bodies giving out powerful radiations, such as the sun for example, would repel them long before they came near enough to be damaged, but on relatively cold planets or heavenly bodies on which the conditions are such that life is able to exist, they could be the starting-point of an evolution of life such as that which has taken place on our globe, an evolution similar as regards its starting-point but not necessarily so as regards its products. This is the so-called doctrine of panspermia, according to which life exists throughout the whole universe in the form of minute germs, capable of further development wherever circumstances permit.

The germs themselves, when floating freely in the interplanetary space, would be subjected to a temperature of about —220° C., a temperature at which all chemical reactions are arrested; they would therefore be in a dormant state, in which all vitality was suspended. They could not therefore undergo any process of multiplication in the interstellar space, and if their numbers were not recruited in some way, the stock of germs floating freely in space would diminish continually and would be absorbed and locked up in those heavenly bodies on which the particles could settle. It is therefore necessary to suppose that the germs can be wafted away from worlds on which they have settled and that other worlds besides ours are inhabited by living things. So far as our solar system is concerned, Arrhenius believes that Venus and Mars probably harbour life, but that Jupiter, Saturn, Uranus, and Neptune are not sufficiently cooled to permit of the existence on them of living beings.

How would such a germ be enabled to leave our earth and embark on a voyage in space? Arrhenius supposes that a living particle sufficiently minute might get carried by winds and atmospheric disturbances up into the higher layers of our atmosphere until the radiation-pressure of the sun's rays would be sufficient to counterbalance the attraction of gravity, and that then it would be wafted out into space. An organism detached from our earth by the radiation-pressure of the sun would, according to Arrhenius, cross the orbit of Mars after 20 days, of Jupiter after 80 days, of Neptune after 14 months, and the nearest solar system, Alpha Centauri, could be reached in about 9,000 years. In order to undergo the strongest influence of solar radiation, an organism must have a diameter of 0·16 μ—that is to say, $\frac{1}{156250}$ of an inch.

Such, in its main features, is the doctrine of panspermia advocated by Arrhenius. We may now examine it a little closer with regard to both its details and its consequences. I am not competent to criticise it from the point of view of its physical aspects—that is to say, with regard to the theory of transportation of particles by radiation-pressure; that must be left to the physicists and astronomers, by whom, I believe, it is accepted. I can only deal with it as a naturalist. Our first inquiry is naturally concerning the living germs themselves.

As no one has as yet seen a germ of life at its first arrival on our earth, we can only consider what type of organism amongst those known to us would be capable of quitting the confines of our atmosphere and embarking on a voyage in space. It is clear, I think, that no Protozoan cyst, no ordinary seed or spore of any plant, could be carried off our earth by radiation-pressure, because such organisms would be many times too big to satisfy the physical requirements of the theory. Still more is this true of the ordinary visible forms of animal life; the familiar expression "raining cats and dogs" cannot be taken literally, and the Arrhenian theory offers no prospect that any of us will ever be able to pay a visit to Mars or any other distant world. Even most bacteria would be far too large to be carried off the earth, though possibly some of the minuter forms of micrococci, in the state of spores, might undertake the journey. But I am inclined to think that the only known forms of life which would be capable of such migration are some of the various kinds of "filter-passers," with regard to which our knowledge is slowly increasing, though still very incomplete—namely, those minute forms of life, some of them apparently beyond the range of vision of our highest powers of the microscope, which pass through the bacterial filters. I have dealt with examples of such forms in the case of the so-called Chlamydozoa.

The question arises at this point, what is the size approximately of the smallest bodies that can be seen with our microscopes? I hesitate, before an audience of experts, to pronounce a decided opinion on this point, but I believe that with the best powers of the microscope at present available a body measuring $0{\cdot}1\mu$ ($\frac{1}{250000}$ of an inch) would be just visible, if it were differentiated optically in some way, by staining or refringence, from its surroundings. This is considerably less than the limit of size required by the Arrhenian theory, and an invisible, filter-passing organism would certainly be small enough to be transported by radiation pressure.

So far, then, the Arrhenian theory supports the view that I have put forward above—namely, that the most primitive form of life was a minute speck of substance of the nature of chromatin, since any cytoplasmic organisms known to us, of the type of an amoeba, for example, would be much too large to be propelled by radiation-pressure in space.

In contrast also with the Lankesterian theory, the Arrhenian theory rests on a purely vitalistic basis—namely, on the assumption that living things are fundamentally different in their nature and properties from those that are not living. No generation of the living from the lifeless took place, according to Arrhenius, at any period to which we can throw our thoughts back; if it took place at all, it must have been at a period during or before the beginning of the material universe as we know it. Life carries on its characteristic activities subject to, and restrained by, the physico-chemical laws of matter, but does not owe its origin to those laws, and is not perhaps, in other worlds, bound up with the same forms of matter with which it is connected in ours. The minute chromatin-particle or germ of life might conceivably, on another planet, set in motion vortices of metabolic change quite different from that type with which we are acquainted here. On the other hand, it follows from the theory of panspermia that all forms of life throughout the universe are related, and it is the opinion of Arrhenius that the activities of life are connected inseparably with the protein-compounds.

Let us now try to imagine what was the fate of the earliest germs of life that, on the theory of panspermia, colonised our globe when it was first in a condition to support life. In the first place it may be noted that the filter-passers of our day show by their activities distinct specific differences amongst themselves. It is therefore possible that more than one variety of living particle came to our planet, and that there may have been some selection amongst those that came.

The first need of the tiny germ, when the warmth of our earth awoke its long-dormant activities, would be food. It is possible that some of these heavenly visitors may have acquired already, in another world, the power of constructing organic matter from inorganic; but it is more probable that a supply of organic matter was a necessity for them, since all the filter-passers and Chlamydozoa known to us at present are parasites. We may suppose, therefore, with Sir Ray Lankester, that a certain epoch of the earth's history was favourable to the synthesis of organic matter of at least a certain degree of complexity; and that thus a supply of food was provided upon which the Arrhenian germs were able to make a start. In any case they must have multiplied rapidly, adapted themselves to various modes of life, and given rise by natural evolution to the various forms of life on our globe through an immense period of time. Arrhenius considers that the interval of time between the first appearance of life on the globe and the Cambrian epoch was at least as great as that from the Cambrian epoch to the present day.

In the preceding paragraphs I have tried to set forth critically the two opposed theories of the origin of life, one or the other of which must be true so far as its main thesis is concerned; that is to say, life must either have originated on the earth or have come to it from without. He who would attempt, however, to judge and decide between these two possibilities would be indeed a bold and a rash man. Scientific knowledge of living things is at present much too incomplete in at least two directions to render any such judgment even approximately just. We require a much more exact knowledge of the physical and chemical nature of the living substance and its activities; and we are as yet very ignorant with regard to the simplest forms of life, their occurrence, species, activities and structure. I will only attempt, therefore, to consider some of the consequences of each theory.

On the Lankesterian theory, we can understand why life does not now originate on the earth under ordinary circumstances, natural or artificial; and it follows from the theory that all life known to us has a common origin from a form or forms called into existence at a particular epoch under special circumstances. But if life has been generated from lifeless matter at any time, it should be possible, in the abstract at least, to imitate and repeat the circumstances under which it arose, were they known to us, and thus generate life again.

On the Arrhenian theory, life may have started its development and evolution many times on the earth, and fresh germs may be falling on the earth now. The statements of some of those who have positively affirmed the occurrence of spontaneous generation might be explained, conceivably, by supposing an Arrhenian germ to have fallen into their cultures, though for my part I am much more inclined to attribute their results to untidy and inexact technique.

In short, if life was generated on the earth, it should be possible to generate it again; and if new germs of life are coming to the earth continually, it should be possible at some time to intercept them and examine them; but whether either of these possibilities is capable of ever being realised is more than any man can say.

The two theories bring us down, as I have pointed out, to the bed-rock of philosophical speculation, to the two opposed standpoints of vitalism and mechanism, the difference between which may be illustrated by a fictitious example. Suppose it were possible to imitate artificially the structure and fabric of a living organism, say of some plant, to such a degree of exactitude that the mimic resembled the model not only in the minutest details of structural arrangement of all its parts, but also in the chemical composition, molecule for molecule, in each corresponding part. Would then the mimic have the same properties as the model—that is to say, would our artificial plant be living? Without hesitation the mechanist answers Yes, the vitalist No. To the mechanist, life is the sum of the chemico-physical properties of the various forms of matter composing the living body; to the vitalist, life is something more than that, something which utilises chemico-physical properties as a workman uses his tools, but which is distinct from them.

Since it is impossible to put the matter to a crucial test, each of the two opposed views remains a pious belief merely. For my part I believe that the view which a man holds with regard to the nature of life depends on the inner constitution and fabric, so to speak, of his mind, and not on the reasoning process. A man is born a vitalist or a mechanist before ever he has thought about such matters, and to argue on the subject is futile. At a time when I was younger than I am now, I have myself debated and discussed such matters hotly; like old Khayyám—

> Myself when young did eagerly frequent
> Doctor and Saint, and heard great Argument
> About it and about: but evermore
> Came out by the same Door as in I went.

It is my present belief that all that is gained by such discussions is to enable a man to ascertain what is the type of mental bias with which he has come into being. The questions which lie at the base of the difference of opinion are at present not capable of being put to the test; and so far as one can see, they seem likely to remain for ever the most inscrutable of problems.

ON THREE NEW SPECIES OF CALLIDINA.

By David Bryce.

(*Read March 26th*, 1912.)

Plate 12.

The description of three new species of Bdelloid Rotifera affords an opportunity of recommending attention to the form of the Upper Lip as one of the most valuable characters which go to make up the individuality of species of the Philodinidae. The earliest mention of this structure which I have found is by Milne (**18**), who early in 1886 referred to it as the "brow," and very briefly pointed out its different forms in three species then described. Later in the same year Zelinka (**20**) named it the Upper Lip ("Oberlippe"), and made use of it in his descriptions of two new species; and again, in 1891 (**29**), gave "the form of the corona and of the upper lip" as the third of eleven characters which should be ascertained as far as circumstances permit and included in the description of any species of the genus Callidina.

The upper lip is not possessed by all the Bdelloida, but only by those which constitute the family of the Philodinidae. Although perhaps, strictly speaking, it is not actually a part of the corona, yet it is only visible when the wheel organ is displayed, and it is withdrawn with it within the mouth when the animal resumes its normal or creeping position. That being the case, it is convenient to look upon it as a subsidiary part of the corona, of which in many cases it has become the dominant characteristic (from the point of view of the student).

When the ciliated discs on their pedicels have been pushed forth from the widely opened mouth, the upper lip comes to be visible in direct dorsal view as an unciliated surface of the head in front of the reverted rostrum, merging gradually at either side into the "collar," the wider part immediately succeeding the lateral bases of the pedicels.

In a few of the tube-dwelling species—*Habrotrocha longiceps*, *H. Leitgebii*, etc.—the upper lip has been considerably enlarged so as to become long in proportion to the breadth of the head, a development which is probably directly connected with the "domestic" habits of these species. In most cases, however, the upper lip is represented by a shallow area, whose anterior margin is subject to astonishing variation. It is therefore the outline of this anterior margin which is referred to in descriptions of the upper lip. While experience has shown that one must not absolutely rely upon the constancy of this outline, it has also shown that variation therein is most infrequent among individuals of one species, whilst there is scarcely any other detail with so wide a range of variation when one species has to be compared with another.

To some extent the outline of the anterior margin appears to vary according to the proximity to each other of the two pedicels. If these are adnate, as in *Habrotrocha pusilla* and other species with very small coronae, or closely proximate, as in *H. constricta*, *Callidina Ehrenbergi* and others, the upper lip is usually centrally prominent or high, frequently attaining to the level of the discs surmounting the pedicels. When, however, the pedicels are widely separated, as in the four-toed genera, Philodina and others, the upper lip is usually of moderate height, seldom rising more than about halfway up the pedicels. On the other hand, whether the pedicels are proximate or remote, several species have an upper lip, which is decidedly low, either showing a slightly convex outline or having a very obtuse median angle. In such cases, when the pedicels are moderately or widely separated, it sometimes happens that the nexus which connects the pedicels, usually at their base, is left exposed in place of being hidden. Again, when the pedicels are rather or very widely separated, the upper lip is most usually carried forward between the pedicels towards the ventral side.

These several forms are complicated by another line of variation, which seems to have deeper significance than the variations of height, and which possibly has no real connection with them. Whether the upper lip be high or low, it is, with few exceptions, more or less obviously bilobed if the species belong to that section of the Philodinidae in which the lumen of the stomach is tube-like. If, on the contrary, the species be a pellet-making form, with the usual more bag-like lumen, then the upper lip is, and I think without known exception, simple and undivided by the faintest furrow or notch. When it is bilobed, the lobes are in some species only very slightly marked, as, for instance, in the genus Rotifer and in *Philodina citrina* and some others, but more usually there is a quite distinct furrow or notch, and in many species the lobes are separated by a relatively wide interspace, more or less flat.

To the general rule that Philodinidae with a tube-like lumen have a bilobed upper lip, perhaps the best-known exception is *Callidina Ehrenbergi*, whose high upper lip forms a single lobe with rounded front. *C. nana* sp. nov., is likewise an exception, and in other respects shows some appearance of close relationship to *C. Ehrenbergi.*

Another exception is found in *C. decora* sp. nov., which, unlike *C. nana*, has widely separated pedicels, but the upper lip rises so slightly as to leave uncovered the nexus between their bases.

The third new species, *C. concinna*, conforms strictly to the rule indicated, the high upper lip being, I think, quite distinctly, though not deeply, notched.

Of these three species, only *C. decora* appears to be uncommon. I have found both the others on several occasions. *C. concinna* is representative of a series of "races," which agreed in the characters specified, but varied somewhat in their size and other details insufficiently important to justify their separation.

The figures of the new species were first drawn to a scale equalling × 800, but have been reduced to the equivalent of × 530.

The numbers after names of authors refer to the Bibliography appended to my paper on "A New Classification of the Bdelloid Rotifera" (*Journ. Quek. Micr. Club*, Ser. 2, Vol. XI. p. 61).

Callidina nana sp. nov. (Pl. 12, Fig. 2).

Specific Characters.—Corona rather narrower than collar; pedicels distinct, closely proximate; upper lip rising nearly as high as discs, narrow, undivided, rounded. Rami with two teeth each. Foot short, of three segments; spurs short acute cones, with little or no interspace. Egg with moderately numerous short blunt spines.

A small and somewhat slender form not uncommon in ground mosses, and occasionally met with in Sphagnum. When creeping about it has much the appearance of a small Habrotrocha, the head and rostrum being a little more elongate than is usual in the genus Callidina. When feeding, the resemblance to the pellet-making genus is again pronounced, the narrow corona and the high upper lip being quite of the Habrotrocha type. The "interference" effects of the flashing cilia and the position immediately below the upper lip of the inner edges of the barely separated pedicels made it extremely difficult to define with reasonable certainty the true outline of the upper lip, but I failed on repeated examinations to distinguish any trace of a notch on the anterior margin. After feeding with carmine I found that the stomach had a very delicate tube-like lumen, within which I could discern particles of pigment circling in the typical manner.

The species seems related to *Callidina Ehrenbergi* Janson, which has the same combination of two-toothed rami, high, undivided upper lip and spinous eggs; but Janson's species is considerably larger, the corona is proportionately wider, the upper lip is more broadly rounded in front and the eggs are covered with numerous spines almost crowded together.

In *C. nana* the egg is of the customary slightly flattened oval form, but is sparsely covered with blunt spines varying in length from 3 to 6 μ according to position, those near the poles being longest, those near the centre the shortest. Including the spines the egg sketched measured about 70 μ long by 41 μ wide.

The animal is generally colourless, or nearly so, the skin more or less finely stippled. It is restless when first put into a small cell, but after a few days' isolation feeds quietly, and endures confinement rather well.

Maximum length, about 220 μ; corona, 20 μ wide; collar, 24 μ; spurs, about 5 μ long.

Originally observed in Sphagnum from Epping Forest, later in various ground mosses, *inter alia* in *Thuidium tamariscinum*, collected for me in St. Leonard's Forest by Mr. A. W. Sheppard.

Callidina concinna sp. nov. (Pl. 12, Fig. 1).

Specific Characters.—Corona moderately narrow, scarcely exceeding collar, pedicels distinct, approximate or little separated. Upper lip high with median notch. Rami two-toothed. Foot of three joints; spurs short cones, divergent, with small or no interspace. Egg oval, smooth, slightly produced, or with low prominence at one or both poles.

In the genus Callidina as now restricted, species with a narrow or small corona are few in number. In the course of examining wall and ground mosses from various localities, I have found several series of examples which agreed approximately in the above characters. My sketches of these animals show them as somewhat dissimilar in their feeding position, but the differences seem to arise only from small variations in the relative distance of the pedicels, in the position and separation of the spurs, and in the size of the rotifer. I cannot find that any of these slightly differing forms have been hitherto described, and I have therefore selected the largest, which I have met with on several occasions, to be the type for a new species.

It is of moderate size, intermediate between *C. habita* and *C. nana*, both in length and stoutness. With the exception of the head and neck, which are rather less stout than is usual in the genus, the general structure is quite typical. The dorsal antenna is moderately short, about one-third of the neck width. I could not definitely see more than three foot joints, but in some cases I thought there were probably four. It is rather active in its movements when disturbed.

Maximum length, about 330 μ; in feeding position figured, about 285 μ; corona, width 41 μ; collar, 38 μ; neck, 32 μ; spurs, 8 μ.

Habitat, in ground or wall mosses.

Callidina decora sp. nov. (Pl. 12, Fig. 3).

Specific Characters.—Of medium size and stoutness. Corona ample. Upper lip undivided, rising in a low curve, showing high nexus between divergent pedicels, widely separated. Rami with two to three teeth. Spurs short cones with moderate interspace.

Several examples of this moderately large form were obtained from moss growing on rocky outcrops near the top of Ben Vrachie, in Perthshire, in 1907. When creeping about they did not show any salient peculiarities, but in the feeding position the unusual form of the upper lip attracted attention. When feeding, the animals assumed a semi-squatting, rather trim and distinctive pose, in which the ample width of the corona became accentuated. The widely separated pedicels are distinctly divergent, although of moderate height. The trochal discs converge slightly to the median line, and have also a moderate dorsal inclination. The secondary wreath does not pass round the pedicels at their bases as is usual, but about one-third of their height up, a peculiarity which I think occurs also in *Mniobia magna* (Plate) and *M. scarlatina* (Ehr.). The nexus between the pedicels is exposed, and so high as to be nearly level with the inner margin of the trochal discs. Centrally it is decorated with two minute fleshy ligules. The upper lip rises in a very moderate curve nearly to the level of the nexus, and shows no trace of notch. As is not unusual, the post-oral segment is withdrawn within the following one when the animal is feeding, the dorsal antenna only being left visible. The rami appeared to be of normal form with the dental formula $\frac{2}{2+1}$. A rather wide stomach lumen could be easily defined. The lumbar plicae persisted in the feeding position. The foot structure was not satisfactorily determined. My impression was that the toes were absent or modified to a sucker-like disc, in which case the species would properly belong to the genus Mniobia, and this relationship receives some support from the position of the secondary wreath. Pending further examination, it seems best to leave the species in the genus Callidina.

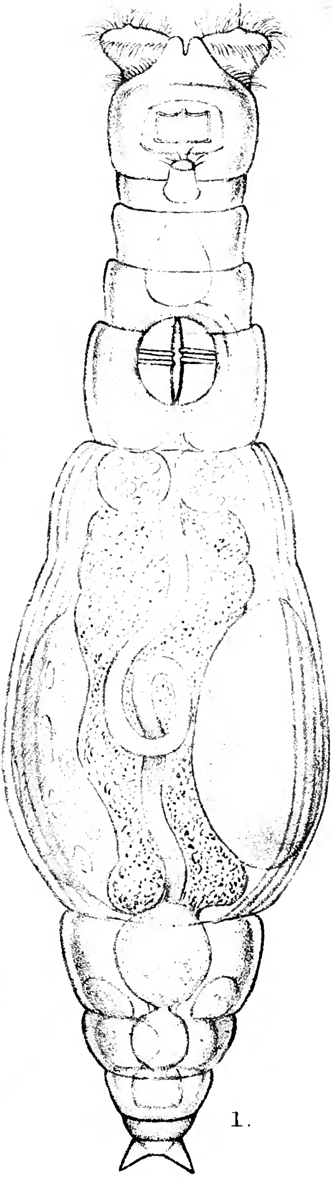
Maximum length not recorded; in feeding position, as figured, about 185 μ; corona, about 63 μ; collar, about 45 μ; spurs, about 5 μ; interspace, 6 μ.

Habitat, as stated above.

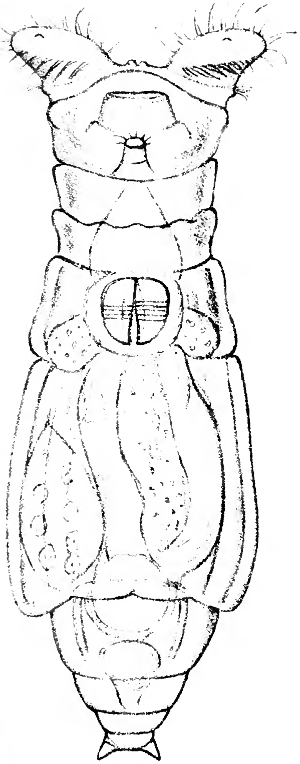
DESCRIPTION OF PLATE 12.

Fig. 1. *Callidina concinna* sp. nov.; *a*, egg.
,, 2. *Callidina nana* sp. nov.; *a*, egg.
,, 3. *Callidina decora* sp. nov.

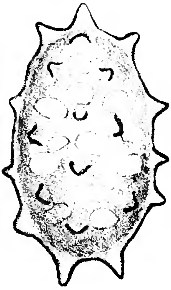
2.



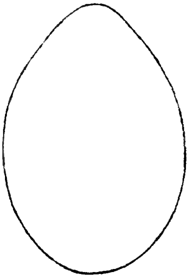
1.



3.



2 a.



1 a.

D. Bryce del. ad nat.

A.H. Searle lith

Callidina, *spp. novæ.*

ON *NOTHOLCA TRIARTHROIDES* SKORIKOW, *CATHYPNA BRACHYDACTYLA* STENROOS, AND ON A NEW BRACHIONUS FROM DEVIL'S LAKE, NORTH DAKOTA.

BY CHARLES F. ROUSSELET, F.R.M.S.

(*Read March 26th*, 1912.)

PLATE 13.

Notholca triarthroides Skorikow (Plate 13, figs. 1, 1*a*).

IN 1905 A. S. Skorikow gave a description * of a strange species of Notholca, which he had found in the River Neva near St. Petersburg, in April 1903, and to which he gave the name *Notholca triarthroides.* About the same time Dr. Skorikow sent me a few specimens for mounting, and before returning the mounted slide I forwarded it to Mr. Dixon-Nuttall, who made the accompanying sketch (Plate 13, Fig. 1) of this peculiar Rotifer. As a figure of it has not, as far as I know, been published, I take this opportunity of supplying the omission.

I am very strongly of opinion that every description of a new Rotifer should be accompanied by a good figure, because a drawing gives a much better idea of the creature, and is always remembered, whilst a description without figure is usually lost sight of and forgotten.

According to Skorikow's description, the three long, thin and curved appendages, two lateral and one posterior, are movable, in the same way as are the two small lateral spines in *Notholca spinifera* ; but farther on the author states that he has not seen the posterior spine move, so there appears to be uncertainty as to whether the posterior appendage is really capable of movement, which I much doubt.

By means of the spines the animal is said to be capable of jerky forward movements in the manner of a Triarthra.

The lorica is very thin, resembling in this respect the marine plankton forms; it is oval in shape, with a high and rounded

---

* "Beobachtungen über das Plankton der Newa," *Biol. Centralblatt.* xxv. 1905, pp. 1–19.

back, and has six fine longitudinal markings. The occipital edge is armed with six spines; the ventral plate is flat, and gapes posteriorly. Size of lorica, exclusive of spine, $\frac{1}{120}$ in. (212 μ).

Cathypna brachydactyla Stenroos (Plate 13, fig. 3).

This rare species was first figured and described by Stenroos* in 1898 from Finland, but does not appear to have been recorded since. Recently I found a few specimens in material collected by R. Lucks in a pond in the Ottominer Marsh near Danzig, which enables me to extend, and in some respect correct, Stenroos's description of this somewhat peculiar little Cathypna.

As will be seen by the figure (Plate 13, Fig. 3) drawn by Mr. A. R. Hammond, the hyaline lorica is broad and oval in shape, but flat and compressed dorso-ventrally, with but a slight convexity dorsally, as shown in the longitudinal and transverse sections, Figs. 3*a*, 3*b*.

The dorsal plate is less wide and considerably shorter than the ventral plate, terminating posteriorly in a straight line just over the foot opening. Anteriorly this plate has a wide, straight, and slightly undulate margin, with sharp points on either side, which are clearly seen when the animal is contracted, contrary to Stenroos's description.

The ventral plate is more deeply excavated anteriorly, and posteriorly terminates in a fairly wide, short and flat appendage, which is cut off nearly straight, with a very slight curve inward; it extends some little distance beyond the foot-opening. The two plates of the lorica are connected with a flexible membrane on both sides and also posteriorly, and the line of inangulation can readily be traced all round. Stenroos does not mention these details, but they are clearly indicated in his figure.

The foot-opening is situated on the under side of the flat ventral plate, some little distance from the posterior margin. The foot consists of a single, short, square joint, and carries two very short stiletto-shaped, acutely pointed toes, which project only with their points beyond the posterior appendage; the toes are cylindrical, not flat blades.

Stenroos further states that in life this Rotifer projects its

---

* "Das Thierleben im Nurmijärvi-See," *Acta Societatis pro Fauna et Flora Fennica*, xvii. 1898, p. 160.

head considerably through the wide frontal opening of the lorica; he has also seen a red eye over the anterior part of the large mastax, which I have been unable to find in the preserved and retracted specimens.

The stomach and intestine lie on the right side, and the ovary, with large nuclei, on the left side of the body cavity.

The size of the three specimens which I have seen measured $\frac{1}{169}$ in. ($150\,\mu$) in length, $\frac{1}{220}$ in. ($115\,\mu$) in width, and the toes $\frac{1}{635}$ in. ($40\,\mu$) long.

Stenroos's animals appear to have been a little larger—namely, $174\,\mu$ long, $135\,\mu$ wide and the toes $34\,\mu$ long.

Brachionus spatiosus sp. nov. (Plate 13, fig. 2).

This striking form I found in plankton material collected by Professor R. T. Young in the Devil's Lake, North Dakota, in July 1910, associated with three other rare Rotifers—namely, *B. satanicus*, *Pedalion fennicum* and *Asplanchna Silvestrii*.

As will be seen from the figure kindly made for me by Mr. A. R. Hammond, the lorica is very wide posteriorly, twice to nearly three times as broad as the anterior region, giving the animal a peculiar and characteristic triangular form. Young animals are not quite so broad in proportion. The six occipital spines (Fig. 2*b*) are of the peculiar saw-tooth pattern as met with in *B. Mülleri*, but considerably larger in size. The scalloped pectoral edge has four rounded, slightly irregular projections as shown in the figure. The posterior corners of the lorica are rounded off, and the foot-opening has thickened edges, is square dorsally and pointed and V-shaped ventrally.

As a whole the lorica is roomy, high and rounded dorsally and nearly flat ventrally, similar in these respects to that of *B. Mülleri*. Like the latter, *B. spatiosus* is a brackish water form, for the water of Devil's Lake is distinctly brackish, which no doubt also accounts for the fact that it contains but few species of Rotifers, and no distinctly fresh-water forms, at least as far as the investigation of its fauna has extended.

The lorica is thin, transparent and free from stipples and posterior spines. The internal organs are quite normal; the foot is fairly long and wrinkled, with the usual two toes.

In shape and appearance the nearest forms are probably

B. latissimus and *B. longipes*, of Schmarda. The former is considerably broader than long, and coarsely stippled on dorsal surface; the second is trapezoidal in shape, the mental edge slightly curved, with small notch in the middle, and the foot opening semicircular; in all these characters they differ from *B. spatiosus*.

I was in doubt at first whether this form should not be called a variety of *B. Mülleri*, with which structurally it is undoubtedly more nearly allied than with any other species; but after comparing it with the mounted specimens in my collection from various localities, I have decided to give it specific rank on account of its striking shape.

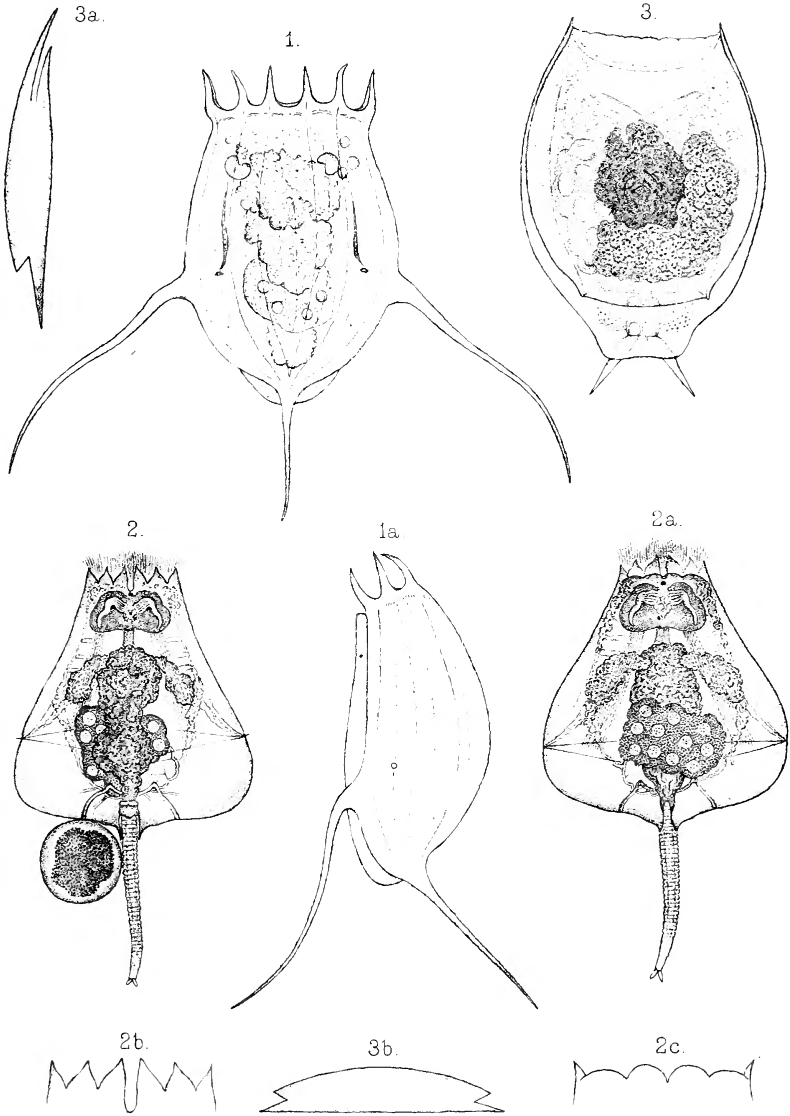
Males were not found in the gathering; summer eggs were carried posteriorly in the usual way, but no resting egg was observed.

Size of lorica of largest specimens: length $\frac{1}{78}$ in. (326 μ), greatest width posteriorly $\frac{1}{79}$ in. (320 μ), width anteriorly $\frac{1}{220}$ in. (115 μ).

Habitat: Devil's Lake, North Dakota, U. S. America.

DESCRIPTION OF PLATE.

Fig. 1. *Notholca triarthroides* Skorikow, dorsal view, × 200.
,, 1*a*. *Notholca triarthroides* Skorikow, side view, × 200.
,, 2. *Brachionus spatiosus* sp. nov., dorsal view, × 105.
,, 2*a*. *Brachionus spatiosus* sp. nov., ventral view, × 105.
,, 2*b*. *Brachionus spatiosus* sp. nov., the occipital spines, × 200.
,, 2*c*. *Brachionus spatiosus* sp. nov., the pectoral edge, × 210.
,, 3. *Cathypna brachydactyla* Stenroos, dorsal view, × 290.
,, 3*a*. *Cathypna brachydactyla* Stenroos, longitudinal section, × 290.
,, 3*b*. *Cathypna brachydactyla* Stenroos, transverse section, × 290



F. R. Dixon-Nuttall and A. R. Hammond del. ad nat.

A. R. Hammond lith.
West, Newman imp.

Rotifera.

LAGENAE OF THE SOUTH-WEST PACIFIC OCEAN.

FROM SOUNDINGS TAKEN BY H.M.S. *WATERWITCH*, 1895.

By Henry Sidebottom.

(*Read March 26th*, 1912.)

Plates 14—21.

INTRODUCTION.

After the lamented death of my friend Mr. W. Blundell Thornhill, of Castle Cosey, Castle Bellingham, Ireland, his magnificent collection of Lagenae was presented to me by his widow, the understanding being that I should write an account of it.

This paper is the first instalment and deals with one set of gatherings only. The specimens are arranged on slides, each of which is divided into one hundred squares. Each set of gatherings has its own chart, showing the stations where the different forms were obtained, but it is not possible in the majority of cases to tell at which station each individual specimen was found, for they were not arranged with that object. Of course, where there is only a single example on a square, or when a form occurs at a single station only, there is no difficulty. This particular set occupies about 380 squares on the slides, each square representing a different species, or variety.

It would have been a delightful task to figure a greater number of the variations, if only with the object of showing how many of the so-called *species* run into each other; but this was impossible considering the amount of work that lay before me. The localities and depths are copied from Mr. Thornhill's book of reference.

It was his intention to arrange all his Lagenae upon a fresh system, using only a very few specific names and introducing all the rest as variations. Among his papers are a couple of pages of manuscript, showing he was evidently commencing to put his ideas into order. The following passages occur: "Of course all forms are related to one another, and run into one another, but there is only one Lagena in many shapes and forms, just as there is only one House, but many forms and shapes of houses. For many reasons, it may perhaps be proved eventually that the shape of the test actually depends on some recognisable fact." Again: "Whether or not the depth at which these Lagenae were living has anything to do with it or not, one is struck by the great numerical superiority of the flattened species to the typically globular, and the comparative rarity of tests without striations, carinations or ornament of some sort."

I am greatly indebted to my friend Mr. Millett for his valuable advice, his unfailing courtesy and for entrusting to me the section **Lagena** of his monograph of the Foraminifera, into which he has copied drawings of all the known species.

My thanks are also due to Prof. Hickson, of the Victoria University, Manchester, for his kind assistance in selecting suitable names for many of the new forms.

No doubt my work is open to criticism, but with all its shortcomings I trust it will be acceptable to my co-workers, and will help to extend the interest in this particular genus of the Foraminifera.

H.M.S. "WATERWITCH." S.W. PACIFIC.

Nos.	Stations.	Localities and Depths in Fathoms.			
1.	157, 161, 168, 170.	18·57′ S. 179·44′ E.	fms. 1,818.	18·59′ S. 179·47′ E.	fms. 1,432.
		18·59′ S. 179·50′ E.	fms. 1,710.	19·3′ S. 179·55′ E.	fms. 1,600.

Nos.	Stations.	Localities and Depths in Fathoms.			
2.	159.	19·04′ S. 179·13′ E.	fms. 1,050.		
3.	180, 181, 183.	13·33′ S. 178·1′ W.	fms. 1,440.	13·18′ S. 177·50′ W.	fms. 1,250.
		12·49′ S. 177·29′ W.	fms. 1,880.		
4.	186.	12·21′ S. 177·10′ W.	fms. 1,730.		
5.	189, 192, 193, 200.	11·52′ S. 176·28′ W.	fms. 2,180.	11·28′ S. 175·47′ W.	fms. 2,290.
		11·54′ S. 176·03′ W.	fms. 2,275.	11·45′ S. 176·43′ W.	fms. 2,150.
6.	190.	11·26′ S. 176·27′ W.	fms. 1,985.		
7.	202, 205, 206.	10·59′ S. 176·36 W.	fms. 1,910.	11·40 S. 177·05 W.	fms. 2,042.
		11·55′ S. 177·18′ W.	fms. 1,989.		
8.	209.	12·18′ S. 177·38′ W.	fms. 525.		
9.	213.	12·30′ S. 177·53′ W.	fms. 1,595.		
10.	215.	12·15′ S. 177·44′ W.	fms. 1,455.		
11.	219.	12·22′ S. 117·39′ W.	fms. 541.		
12.	221.	12·35′ S. 177·38′ W.	fms. 620.		
13.	238.	12·44′ S. 178·09′ W.	fms. 1,050.		
14.	239.	12·55′ S. 178·13′ W.	fms. 1,630.		
15.	241.	13·22′ S. 178·38′ W.	fms. 1,475.		
16.	242.	13·42′ S. 178·47′ W.	fms. 822.		
17.	243, 245, 246.	13·55′ S. 178·56′ W.	fms. 1,115.	14·33′ S. 179·21′ W.	fms. 1,410.
		14·52′ S. 179·32′ W.	fms. 1,395.		
18.	248, 249.	15·24′ S. 179·46′ W.	fms. 1,472.	15·35′ S. 179·47′ W.	fms. 1,675.
19.	250.	15·43′ S. 179·43′ W.	fms. 820.		
20.	256.	16·9′ S. 179·47′ E.	fms. 505.		

Nos.	Stations.	Localities and Depths in Fathoms.			
21.	258, 260.	16·5′ S. 179·36′ E.	fms. 484.	16·7′ S. 179·28′ E.	fms. 533.
22.	264.	16·15′ S. 179·16′ E.	fms. 148.		
23.	275, 276.	18·57′ S. 177·36′ E.	fms. 1,195.	19·17′ S. 177·15′ E.	fms. 1,679.
24.	284.	25·03′ S. 171·37′ E.	fms. 2,310.		
25.	286.	26·27′ S. 170·17′ E.	fms. 2,033.		
26.	289.	28·30′ S. 168·23′ E.	fms. 1,745.		
27.	291.	29·00′ S. 166·50′ E.	fms. 1,950.		
28.	293.	29·2′ S. 163·59′ E.	fms. 1,225.		
29.	295.	29·3′ S. 162·24′ E.	fms. 710.		
30.	298, 300.	28·52′ S. 159·57′ E.	fms. 1,575.	28·53′ S. 158·6′ E.	fms. 1,612.
31.	301.	28·47′ S. 157·02′ E.	fms. 2,515.		
32.	302.	28·43′ S. 155·45′ E.	fms. 2,378.		
33.	303.	28·35′ S. 154·49′ E.	fms. 2,565.		
34.	304.	28·43′ S. 154·11′ E.	fms. 1,425.		

Where more than one station is indicated above, it shows that the samples have been mixed.

Family LAGENIDAE.

Sub-family **Lageninae**.

Lagena Walker and Boys.

Lagena globosa Montagu sp. (Pl. 14, figs. 1–6).

Serpula (*Lagena*) *laevis globosa* Walker and Boys, 1784, *Test. Min.*, p. 3, pl. 1, fig. 8.

Vermiculum globosum Montagu, 1803, *Test. Brit.*, p. 523.

In these gatherings, *Lagena globosa* is present in a great variety of forms. Besides the strictly globular, sub-globular, ovate and pyriform, there are specimens that run into *L. laevis* and *L. apiculata*. The internal tube, when present, often differs in character, and may be free or attached to the test. The orifices of the various forms also vary greatly. The tests are sometimes wonderfully transparent, thin and highly polished, at other times thick and opaque.

Pl. 14, fig. 1 is doubly entosolenian, orifice fissurine.

Pl. 14, fig. 2 is globular, and has the sides of the projecting mouth much flattened, causing the orifice to be a very narrow slit. There is a pinching in of the sides of the mouth at the centre, which apparently divides the orifice into two parts.—*Locality:* Uncertain.

Pl. 14, fig. 3 has a circle of projecting points surrounding the simple aperture. There is no internal tube. Very rare.—*Locality:* Uncertain.

Pl. 14, fig. 4 is globular, and has a hood in which the orifice is situated. I cannot give the exact locality for this globular form, but there is a variety, very similar, which occurs at many stations, the chief difference being that the test is slightly elongate, tapering towards the oral end, and so causing the hood to be less pronounced. A few are very slightly compressed.—*Locality:* Chiefly Nos. **30**, **32**.*

Pl. 14, fig. 5 is the compressed variety of fig. 4.—*Locality:* Chiefly Nos. **2**, **17**.

Except that the tests are not partially carinate, these two

---

* Note.—The numbers throughout this work refer to my Chart on pp. 376–8, where will be found the official numbers of the stations with other particulars.

forms, figs. 4, 5, agree well with *L. ventricosa* Silvestri (1903), figs. 6*a–e*.

Pl. 14, fig. 6, has a band of clear shell-substance running round the test and orifice. Orifice fissurine. Only five found. There appears to be no internal tube.—*Locality :* Uncertain.

Lagena globosa Montagu sp. (Pl. 14, figs. 7–9, bilocular forms, figs. 7, 8).

I think there is no doubt that figs. 7, 8 represent *L. globosa* in the bilocular state, and they are interesting from several points of view.

There are only six recorded from these gatherings, but many more occur in the *Penguin* collection. Taking the two together one could arrange a complete series as regards size, from the smallest to the largest. In the smallest tests (single-chambered) fig. 9, a portion of the oral end appears to be solid except for the tubular passage through its centre, and the entosolenian tube is not always present. As regards these it is possible that they bear no relation to the bilocular examples, but they have every appearance of doing do. If I am right in my surmise it would appear that the animal had the power of expanding the solid portion at the oral end into a second chamber, and this would imply that it also increased the size of the initial chamber, for the second is never present in the smallest size. In the bilocular forms the solid portion is absent in both chambers.—*Locality :* Odd specimens only at Nos. **1, 3, 18, 28, 29, 30.**

Lagena globosa Montagu sp. var. nov. *maculata* (Pl. 14, figs. 10, 11).

Test globular or sub-globular, generally transparent, with four small, oval, opaque spots, placed equidistant from each other round the middle of the test, or slightly above the middle. Entosolenian, the tube being free and curiously coiled back upon itself. Aperture fissurine. Very rare.—*Locality :* Nos. **1, 32.**

Lagena globosa Montagu sp. var. nov. *annulata* (Pl. 14, fig. 12).

Test globular, entosolenian. A rather opaque band or ring surrounds the test near its base.

The tube is coiled back upon itself. The orifice is situated in a small depression. A solitary specimen.—*Locality:* No. **6.**

Lagena globosa Montagu sp. var. *emaciata* Reuss. (Pl. 14, figs. 13–15).

Lagena emaciata Reuss, 1862 (1863), p. 319, pl. 1, fig. 9.

There is present in these gatherings a very fine series of this elongate form of *L. globosa.* It occurs at many stations. There is a complete gradation of forms right up to fig. 14, which corresponds to *L. ovum.* As one would expect, several are pointed at the base, as in fig. 15. In figs. 13 and 15 the aperture is fissurine, and in fig. 14 it has three radiating fissures. The internal tube is straight and free. — *Locality:* Chiefly Nos. **19, 20, 29.**

Lagena apiculata Reuss. (Pl. 14, figs. 16–20).

Oolina apiculata Reuss, 1851, p. 22, pl. 1, fig. 1.
Lagena apiculata Reuss, 1862 (1863), p. 318, pl. 1, figs. 1, 4–8, 10–11.

Mr. Millett, in his Malay Report under this heading, remarks, "Bearing in mind that most, if not all, of the Lagenae have their apiculate condition, it seems unnecessary to endow each with a separate name; but pending an entire reform of the classification, it may cause less inconvenience for the present if these names be retained." It is difficult to deal satisfactorily with the apiculate forms in these gatherings. One cannot in many cases draw a line of demarcation between the apiculate and non-apiculate forms, as they pass insensibly into one another. I am not sure, however, if some distinction may not have to be made when the apiculate portion is a tube, instead of being solid. I do not think the position, or nature, of the aperture, or the slight curving of the test sufficient to warrant the giving of a specific name. For those who take an opposite view there is a fine field open in these S.W. Pacific gatherings. Beautiful examples occur like those represented by figs. 16–18. I place them under this heading, but to me they seem to be as follows:

Pl. 14, fig. 16. A doubly ectosolenian, and entosolenian form of a typical *L. globosa.*

Pl. 14, figs. 17, 18. Entosolenian and ectosolenian variety of the same, the apiculate process being a tube in all three cases.—*Locality:* Odd specimens from a few stations.

There is a still larger specimen than fig. 17 with a longer projecting tube at the base, but it is not so globular in shape. There are also two fine apiculate, ovate specimens, one of which has a few subsidiary spines at the base of the test. Specimens from various stations occur similar to figs. 19, 20, the tube being long and slender, the orifice round and placed a little to one side. Some of the tests are asymmetrical like fig. 20, and a few are broader in relation to their height than the two figured.

Lagena apiculata Reuss var. nov. *punctulata*
(Pl. 14, figs. 21–23).

The contour of the test is subject to a good deal of variation; more generally the forms are like figs. 21, 23, but examples that are asymmetrical in outline occur, see fig. 22. Round in section, orifice usually fissurine, but sometimes with three radiating fissures. The whole of the test is covered with large pores. The entosolenian tube is straight and free. This handsome foraminifer may be allied to *Amphorina punctata* Seguenza (1862), pl. 1, fig. 39, and *L. apiculata* (Reuss) Terquem (1886), pl. 1, fig. 5. Most of the tests are pointed at the base, but a few are more or less rounded off.—*Locality:* It is marked to occur at six stations. Three were found at No. **9** and four at No. **18**.

Lagena ovum Ehrenberg sp.

Miliola ovum Ehrenberg, 1843, p. 166;—1854, pl. 23, fig. 2; pl. 27, fig. 1; pl. 29, fig. 45.

This is an unsatisfactory species. See remarks about fig. 14. Besides odd specimens that may be brought under this heading, there are a good number which may, or may not, be single chambers of a Nodosaria. They have a short internal tube, and a small ring at the base. Inside this ring the shell seems to be concave, has a granulated appearance, and may be porous. Some of the specimens are comparatively large, and tend at times to broaden out at the sides.—*Locality:* Chiefly Nos. **19**, **21**, **29**.

Lagena botelliformis Brady (Pl. 14, figs. 24–29).

Lagena botelliformis Brady, 1884, p. 454, pl. 56, fig. 6.

This again is to me an unsatisfactory species to deal with. Mr. Millett in his Malay Report considers it to be more nearly allied to *L. elongata* than to *L. globosa*. There is only one example that agrees with Brady's *Challenger* figure.—*Locality:* Uncertain.

Brady in his description of this form in the *Challenger* Report, p. 454, writes as follows: "Long, cylindrical, of even diameter, arcuate," but in his scheme of the Genus Lagena, also in the *Challenger* Report, it runs: "Cylindrical, or elongate, ovate, bent." I think therefore we may include such forms as I have figured. Chapman (1910), pl. 54, fig. 5, illustrates an example from material collected by H.M.S. *Penguin* near Funafuti, which is evidently of the same variety as those met with in these gatherings. I have also another large set of Lagenae, picked out of material collected by the *Penguin*, in which this variety is also frequent.

Pl. 14, fig. 24 is nearest to Chapman's figure, but the tests are more frequently similar to fig. 25. The aperture is placed at the bottom of a shallow hood.—*Locality:* It occurs at nearly all the stations, including Nos. **1, 17, 19, 21, 29.**

Pl. 14, fig. 26 is a very elongate variety.

Pl. 14, figs. 27, 28 appear to be weak, apiculate examples.—*Locality:* At No. **7,** one example; No. **11,** five; No. **14,** one.

Pl. 14, fig. 29, I take to be a slight variation of fig. 24. There are four sets of opaque, oval dots which run lengthwise, two rows on either side. The base is inclined to be pointed. It is very rare.—*Locality:* At No. **3,** one specimen; No. **23,** three.

Fornasini (1894), under the heading of *L. felsinea*, figures a form that appears to be very near to Chapman's and to my own fig. 24, the chief difference being that the aperture of his specimen is fissurine.

Lagena botelliformis Brady (?) var. nov. *rugosa* (Pl. 14, fig. 30).

Test cylindrical, curved, rugose. There is a short, tubular neck with a small "boss" at the end, in which the aperture is placed.

I cannot make out the nature of the shell-wall. The surface is roughened, and it will be noticed that in the drawing the oral end of the test is partially eroded, and it looks as if the wall might be compound. I have placed it under the above heading provisionally.—*Locality:* No. **2**. A solitary specimen.

Lagena laevis Montagu sp.

Serpula (*Lagena*) *laevis ovalis* Walker and Boys, 1784, p. 3, pl. 1, fig. 9.

Lagena laevis (W. and J.) Williamson, 1848, pl. 1, figs. 1, 2.

They range from those having the body of the test globular, with either short or long neck, to those in which the body is subfusiform. These latter are apiculate, the process being a solid spine.—*Locality:* Various stations.

Lagena laevis Montagu sp. var. *distoma* Silvestri.

Lagena laevis (Montagu) Silvestri, 1900, p. 244, pl. 6, figs. 74, 75.

Locality: Occurs at a few stations.

Lagena gracillima Seguenza sp.

Amphorina gracilis Costa, 1856, p. 121, pl. 11, fig. 11.

Amphorina gracillima Seguenza, 1862, p. 51, pl. 1, fig. 37.

A single example only.—*Locality:* Either No. **19** or **20**.

Lagena elongata Ehrenberg sp.

Miliola elongata Ehrenberg, 1854, pl. 25, 1 A, fig. 1.

Only one occurs and it agrees very closely with Mr. Millett's illustration, Malay Report, 1901, pl. 8, fig. 10.—*Locality:* Either No. **19** or **20**.

Lagena aspera Reuss.

Lagena aspera Reuss, 1861, p. 305, pl. 1, fig. 5.

A single specimen, and it is similar to the *Challenger* figure, pl. 57, fig. 7, except that the body of the test is more elongate. The neck is broken.—*Locality:* No. **19**.

Lagena ampulla-distoma Rymer Jones.

Lagena vulgaris var. *ampulla-distoma* Ry. Jones, 1872, p. 63, pl. 19, fig. 52.

Many specimens are on the slide, and they show considerable variation both in the size of the test and the nature of the mammilate aperture. Specimens occur that are nearly smooth, and sometimes the lower half of the test is covered with short, blunted spines.—*Locality:* Chiefly Nos. **1**, **2**, **19**, **22**.

Lagena hispida Reuss (Pl. 14, fig. 31, Pl. 15, fig. 1).

Sphaerulae hispidae Soldani, 1798, p. 53, pl. 17, v, x.
Lagena hispida Reuss, 1858, p. 434.

There are three very large specimens with the body of the test globular. The necks are long and decorated with short, blunt spines. One is apiculate.—*Locality:* No. **1**.

Many specimens similar to the *Challenger* fig. 2, pl. 57, are present, some of which are almost covered over with exogenous shell-growth, or a deposit of some description.—*Locality:* Many stations, but chiefly at Nos. **21**, **29**, **32**.

Pl. 14, fig. 31. There are numerous examples, globular and sub-globular. The entosolenian tube is long and straight. At the aboral end of the test the apiculate process is tubular, and often of considerable length. The examples are beautifully hispid; but in spite of the spines, the long, straight, entosolenian tube can be made out.—*Locality:* Five at No. **1**, and one or two at fifteen other stations.

Pl. 15, fig. 1 is round in section and apiculate, the circular orifice being sunk in a square, the corners of which end in spines that are curved downwards.—*Locality:* Two at No. **17** and one at No. **32**.

Lagena hispida Reuss, compressed variety (Pl. 15, fig. 2).

There are a large number of this compressed variety. The orifice is slightly phialine, and the test is bluntly apiculate. Many of the specimens are clogged with exogenous matter, and when in this state the fine, hair-like spines often project a considerable distance.—*Locality:* Chiefly Nos. **1**, **3**, **13**, **17**, **30**, **32**.

Lagena hispida Reuss var. nov. *tubulata* (Pl. 15, figs. 3—5).

The test, besides being covered with long delicate spines (when in its perfect state) has strong tubular ones arranged symmetrically upon it, as shown in the drawings. The neck is long, sometimes bent.

Pl. 15, fig. 4 is the same; the spines are broken away. Many of the tests have the neck broken.—*Locality:* Five at No. **3**, two at No. **13**, five at No. **17**, and odd specimens at several other localities.

Pl. 15, fig. 5 is, I think, a variation. The long spines are much finer, and finish with a point when perfect, but when broken appear to be tubular. The neck gradually tapers to a point. The specimens are not in a good condition.—*Locality:* Chiefly Nos. **8, 11, 13, 17**, and one or two occur at a few other localities.

Lagena striata d'Orbigny sp. (Pl. 15, figs. 6–10).

Oolina striata d'Orbigny, 1839, p. 21, pl. 5, fig. 12.

I consider that the serial connection between *L. sulcata*, *L. striata* and *L. gracilis* is complete in these S.W. Pacific gatherings. *L. striata* is present in many beautiful forms and at many localities. The shape of the test varies from the globular to the cylindrical, and is often apiculate. The decoration of the tests is at times most delicate, and links up to *L. sulcata*. The beautiful spiral bands which often decorate their necks are sometimes of extreme fineness. Numerous examples range round *L. lyelli* Seguenza (1862), which is typically represented.

Pl. 15, fig. 6. There are about twenty-six of this small variety, the short neck of which is crowned with a minute "boss." The orifice is circular. The tests are generally round in section, but some are just a little compressed. At times, several of the costae are rather more prominent than the rest.— —*Locality:* Chiefly Nos. **1, 3, 17**.

Pl. 15, fig. 7. In these, five of the costae, equidistant from each other, project more than the remainder.—*Locality:* Chiefly Nos. **19, 21**.

Pl. 15, fig. 8. This specimen has the apiculate process of extreme length.

Pl. 15, fig. 9, is the same as the *Challenger* figure, pl. 57, fig. 30, which Brady places under this heading. Only one occurs. —*Locality:* No. **20**.

Pl. 15, fig. 10. Seems to be another variant. One only occurs. —*Locality:* No. **30**.

Lagena striata d'Orbigny var. nov. *striatotubulata* (Pl. 15, figs. 11, 12).

Body of the test nearly globular, or ovate. Round in section. Numerous fine costae run lengthwise of the test, some of which do not reach as far as its base. Neck long, and provided with from four to six wings, starting part way up the neck, and reaching down to the middle of the test. In some cases they run down along the sides to join the long, projecting tubular processes at the base. The number of the tubular processes varies from four to six. Sometimes these tubes are flattened. There are a good number of this elaborate form; some are in perfect condition, but most of them are a good deal broken, and the adherence of debris interferes with their elegance. Brady's *Challenger* figure, pl. 57, fig. 29, appears to belong to this series, although it is probably a broken and poor example.—*Locality:* Chiefly No. **32**, and rarely at many other stations.

Lagena distoma Parker and Jones.

Lagena laevis var. *striata* Parker and Jones, 1857, p. 278, pl. 11, fig. 24.

There are only ten or eleven examples on the slide, although many more are indicated on the chart.—*Locality:* Chiefly No. **21.**

Lagena variata Brady (Pl. 15, fig. 13).

Lagena variata Brady, 1881, *Quart. Journ. Micr. Sci.*, N.S., vol. xxi., p. 61.

Lagena variata Brady, 1884, p. 461, pl. 61, fig. 1.

There are only two typical examples. They are irregular in shape.—*Locality:* One, No. **3**, the other uncertain.

Pl. 15, fig. 13. There are a fair number of small specimens in which the striae or fine costae are generally much broken up. Most of the tests have a short neck, only just showing; in the one figured it is more pronounced than is usually the case. The tests are regular in shape.—*Locality:* Chiefly No. **15.**

Lagena lineata Williamson sp. (Pl. 15, figs. 14, 15).

Entosolenia lineata Williamson sp., 1848, p. 18, pl. 2, fig. 18.

The typical form occurs rarely, but at a good many localities. Odd specimens appear to be non-apiculate, like fig. 14. This species seems to pass insensibly into *L. costata.*

Pl. 15, fig. 15 shows the lines assuming an **S**-shaped condition. —*Locality :* Occurs rarely at two or three stations.

It is impossible in certain cases to separate the striate from the very finely costate forms, but many are undoubtedly costate. They are rarely in the apiculate condition.

Lagena costata Williamson sp. (Pl. 15, figs. 16–20, 21).

Entosolenia costata Williamson, 1858, p. 9, pl. 1, fig. 18.

The specimens are numerous. Both the strength of the costae and their number vary greatly. Type specimens are present.—*Locality :* Various stations.

The following are interesting examples :

Pl. 15, fig. 16. This has a slightly projecting ring at the base.—*Locality :* About a dozen from various stations.

Pl. 15, fig. 17. An odd specimen.—*Locality :* No. **29.**

Pl. 15, fig. 18. In this the costae are only six in number. Only one occurs.—*Locality :* Uncertain.

Pl. 15, fig. 19. In this the costae are curved and well developed. Only one found. Orifice circular.—*Locality :* The exact locality is uncertain.

Pl. 15, fig. 20. In this some of the costae only reach part way down the test. The mouth is circular. There are two or three specimens on the slide.—*Locality :* Exact locality uncertain.

Pl. 15, fig. 21. As there is only a single specimen to judge by, and that one somewhat asymmetrical, it is placed here with a query against it. It is quite opaque. The orifice is a simple opening, with three radiating fissures. I thought it might possibly be a seed case, but on touching it with hydrochloric acid I found that it at once effervesced. It seems to be allied to *Trigonulina globosa* Seguenza, 1862, pl. 2, figs. 60–62.—*Locality :* No. **3.**

Lagena acuticosta Reuss (Pl. 15, figs. 22, 23).

Lagena acuticosta Reuss, 1861, p. 305, pl. 1, fig. 4.

This is an unsatisfactory species, for it is simply a form of *L. costata.* The few specimens that occur are similar to the *Challenger* figure, pl. 58, fig. 21.

Pl. 15, fig. 22 is practically the same as the *Challenger* figure, pl. 57, fig. 32.—*Locality :* No. **3.**

Pl. 15, fig. 23. This appears to be a weak and rotund form of the type, having only three costae.—*Locality :* No. **3**. Only one occurs.

Lagena melo d'Orbigny sp.

Oolina melo d'Orbigny, 1839, p. 20, pl. 5, fig. 9.

Only a few occur.—*Locality:* Exact locality uncertain.

Lagena hexagona Williamson.

Entosolenia squamosa var. *hexagona* Williamson, 1848, p. 20, pl. 2, fig. 23.

The examples are small. Some are globular, and a few take the form of *L. laevis*, having a well-produced and transparent neck.—*Locality :* Uncertain.

A compressed form is present. The specimens are very small, almost circular in outline and compressed. Orifice fissurine.—*Locality :* Uncertain.

Lagena seminuda Brady.

Lagena seminuda Brady, 1884, p. 472, pl. 58, fig. 34.

There is only a solitary specimen of this beautiful form. The test is fractured, showing the wall to be very thick.—*Locality :* No. **28**.

Lagena sulcata Walker and Jacob sp. (Pl. 15, figs. 24, 25).

Serpula (*Lagena*) *striata sulcata rotunda* Walker and Boys, 1784, p. 2, pl. 1, fig. 6.

Serpula (*Lagena*) *sulcata* Walker and Jacob, 1798, p. 634, pl. 14, fig. 5.

Fine specimens occur, but somewhat rarely. The tests vary greatly in their shape and size, likewise in the number of costae. They are mostly in the apiculate condition.

Pl. 15, fig. 24. This is a stout form, with a few of the costae produced at the base. The short neck is heavily rimmed.—*Locality :* Two at No. **3** and one at No. **8**.

Pl. 15, fig. 25 has tubular spines encircling the base. The test is apiculate. Two occur; one is much damaged, but has the neck straight, and probably had more spines than the one figured. —*Locality :* Nos. **30**, **32**.

Lagena gracilis Williamson.

Lagena gracilis Williamson, 1848, p. 13, pl. 1, fig. 5.

This variable species occurs sparingly at a good many stations. Forms similar to the *Challenger* illustrations, pl. 58, figs. 3, 7, 8, 9 and 23, are present, besides some that tend towards the apiculate form of *L. striata.*—*Locality :* Chiefly No. **17.**

Lagena semistriata Williamson.

Lagena striata var. *β semistriata* Williamson, 1848, p. 14, pl. 1, figs. 9, 10.

The tests, which are not very numerous, vary a good deal in their contour. A few are of the *L. clavata* form; and one or two, with their projecting spines at the base, are very near to *Oolina striaticollis* d'Orbigny, 1839, pl. 5, fig. 14.—*Locality :* Chiefly Nos. **21, 22.**

Lagena thornhilli sp. nov. (Pl. 15, fig. 26).

Body of test globular or slightly ovate, round in section, with long, tubular neck. Three wings, equidistant, run from the orifice to the edge of the test and thence, as a small keel, down to the centre of the base. In each of the three partitions are two raised oval rings, slightly pointed at their ends, one within the other. The wings are sometimes striated. The late Mr. Thornhill was particularly interested in this handsome Lagena, and often spoke of it as the "New Zealand Chief," for it reminded him of the way in which a chief is decorated. I have, therefore, named it after him. It seems to be a winged and varied form of *L. sulcata.* The striae referred to above show in another specimen, which is not in such good condition as the one drawn. Five are marked on the chart as occurring. One is very badly broken and is a doubtful specimen. Two others are broken and not quite typical.—*Locality :* Nos. **2, 3, 6, 7.**

Lagena striato-areolata Rymer Jones (Pl. 15, fig. 27).

Lagena vulgaris Williamson var. *striato-areolata* Rymer Jones, 1872, p. 53, pl. 19, figs. 21, 21*a*.

Body of test ovate, neck long, four small wings start part way up the neck and run down to the sides of the test. About three-quarters of the body is covered with irregular, more or less hexagonal, net-work; the upper portion between the four keels is decorated with a few fine costae. A couple of spines project from the base. A single specimen only. Unfortunately I have lost it, but my drawing of it was finished before this happened. The specimen has the areolations much more extended over the surface of the test than Jones's drawings indicate, otherwise it agrees well with his description.—*Locality:* No. **17**.

Lagena stelligera Brady. (Pl. 15, figs. 28, 29, and Pl. 16, figs. 1–4).

Lagena stelligera Brady, 1881, *Quart. Journ. Micr. Sci.*, vol. 21, N.S., p. 60.
Lagena stelligera Brady, 1884, p. 466, pl. 57, figs. 35, 36.

There is an extraordinary range of variation in this species, if I am right in my diagnosis. About forty examples are on the slide, besides twenty-five of the variety in which the costae at the base are absent. Pl. 15, fig. 28 is drawn from the largest one present, and the tests pass insensibly into such forms as Pl. 15, fig. 29 and Pl. 16, fig. 1. There are examples somewhat similar to Pl. 15, fig. 29, showing the costae bridging the space at the lower part of the body of the test. The variety without costae, Pl. 16, fig. 2, (the absence of which is referred to by Brady in the *Challenger* Report) is represented by both stouter and larger specimens than the one figured, and also by more slender ones. Examples are present that, if found by themselves, might pass for apiculate (tubular) forms of *L. semistriata* or *L. sulcata*, and again others might be placed with *L. gracilis*. These I take to be intermediate forms.

Pl. 16, fig. 1 approaches *L. gracilis*, but there are forms present in which the costae run the whole length of the test, and the tubular, apiculate portion is more slender. In all cases the apiculate process is tubular, and at times funnel-shaped. The entosolenian tube is sometimes straight, sometimes attached to the side of the test. In the larger specimens the tests are opaque. Parker and Jones, 1865, pl. 16, fig. 9, figure a test which in outline is similar to the "nude" form referred to above, but I think they refer it to a "nude" form of *L. caudata* d'Orbigny.

Egger's *L. crenulata*, 1893, pl. 10, fig. 86, may belong to the *L. stelligera* series.—*Locality:* Chiefly Nos. **7, 17, 31, 32**. *Locality:* "Nude" form, chiefly No. **17**.

Pl. 16, fig. 3. In this variation the test is ovate or pyriform. Orifice oval. The internal tube is always coiled back upon itself. The test is smooth and transparent, but apparently when aged it becomes opaque and roughened. Brady states in the *Challenger* Report, p. 466, that "the circular rim varies considerably in depth," and in this case the rim is shallow.—*Locality:* Chiefly Nos. **17, 30, 32**.

Pl. 16, fig. 4 is evidently the compressed variety, and very rare.—*Locality:* Two at No. **29** and odd specimens at four other localities.

Lagena stelligera Brady var. nov. *eccentrica* (Pl. 16, figs. 5, 6).

Test flask-shaped, with or without a true neck. Surface smooth. An irregular ridge encircles the lower part of the base, as shown in the illustration. This ridge occurs also in an oval form. I think most probably these are connected with the "nude" variety of *L. stelligera*. Only four found, of which one is a little compressed.—*Locality:* Nos. **7, 21, 31**.

Lagena exsculpta Brady.

Lagenulina sulcata Terquem, 1876, p. 68, pl. 7, fig. 9.
Lagena exsculpta Brady, 1884, p. 467, pl. 58, fig. 1, pl. 61, fig. 5.

Four only found, and they are all in the compressed condition, as figured by Brady, 1884, pl. 61, fig. 5.—*Locality:* No. **1**.

Lagena striatopunctata Parker and Jones (Pl. 16, figs. 7–10).

Lagena sulcata var. *striatopunctata* Parker and Jones, 1865, p. 350, pl. 13, figs. 25–27.

Pl. 16, fig. 7 has the sides convex. Only one occurs, but a somewhat similar though slenderer form is found at several stations.—*Locality:* Chiefly Nos. **1, 19, 22**.

Pl. 16, fig. 8. This is a stout form, and is evidently the one referred to by Mr. Millett, 1901, p. 489, Malay Report, as having the costae flattened or even hollowed out. Rare. A very similar variety, having the costae thin, is frequent. The two forms are on the same square and so the separate localities cannot be given.—*Locality:* Thirty-seven at No. **19**. Frequent at Nos. **21**, **22**, and a few other stations.

Pl. 16, fig. 9. Very rare.—*Locality:* No. **20** and several others.

Pl. 16, fig. 10 is an exceedingly finely marked variety. The lines of pores lie very close together, and I cannot make out whether they are on a ledge or not. It may be *L. feildeniana*, but I have decided to place it here, on account of the bent neck so often characteristic of *L. striatopunctata*. It is very rare.—*Locality:* Two at No. **19**, and odd specimens at one or two other stations.

Lagena striatopunctata Parker and Jones (?) var. nov. *complexa* (Pl. 16, fig. 11).

This elegant variety has the surface of the costae hollowed out and the spaces between them roughened by granular shell-growth; showing through this are two or three lines of detached, minute tubercles, running lengthwise down the test. The shell-growth does not appear in the drawing, as I wished the tubercles to appear plainly. There is a tendency in this variety to disintegrate, and when this has happened a complete shell-wall is revealed, with many spines attached to it. There is one perfect specimen, and another nearly so. One, which I believe to be the same variety, has only the inner shell left, with many spines and bits of costae. It is just possible that this is a compound-walled Lagena, and therefore I have put a query against it. There are several other Lagenae on the square that do not belong to the same species, and so the exact locality cannot be given.

Lagena striatopunctata Parker and Jones var. nov. *inaequalis* (Pl. 16, fig. 12).

This is a handsome variety. The test near the base is round, or nearly so, in section, but gradually becomes compressed as it approaches the orifice, which is fissurine. From each side of the orifice springs a keel, thickened at the edge, which dies away a short distance down the test. Between the punctate costae there is a very fine short and slightly raised plain costa, which varies in length, but this is not always present. One specimen has three equidistant keels springing from the orifice and running well down the test, and as the whole shell remains round in section, it may be taken as the trifacial form. This was found at No. **7**.—*Locality:* It is marked as occurring at the following: Nos. **3**, **6**, **9**, **10**, **15**, **17**. Very rare. As there are two tests on the square which do not belong to the set, the respective localities become uncertain.

Lagena striatopunctata Parker and Jones var. nov. *fusiformis* (Pl. 16, fig. 13).

There is only one specimen of this beautiful Lagena. It has nine thin costae running lengthwise down the test. The perforations of the costae are very fine, and cause a slight bulging at the sides. My drawing is not delicate enough in this respect. The body of the test is a little roughened and semi-opaque, and this is owing to innumerable fine pores.—*Locality:* No. **1**.

Lagena striatopunctata Parker and Jones var. *spiralis* Brady (Pl. 16, fig. 14).

Lagena spiralis Brady, 1884, p. 468, pl. 114, fig. 9.

Nearly one hundred specimens are on the slide. I remember Mr. Thornhill remarking that he was tired of picking them out. They vary greatly in their contour, and also in the amount of "screw" that the costae take on. In all cases these run a little up the neck, the perforations ceasing before the costae. In one or two instances the perforations are confined to the base of the test, and one or two have the neck bent to one side, as is so often the case in the type form. It is marked to occur at thirteen stations.—*Locality:* Chiefly Nos. **1**, **2**, **19**, **21**, **22**.

Lagena desmophora Rymer Jones.

Lagena vulgaris var. *desmophora* Rymer Jones, 1872, p. 54, pl. 19, figs. 23, 24.

The examples are similar to the *Challenger* illustration, pl. 58, fig. 43. Nine found. In all except one the decoration is confined to the lower half of the test.—*Locality:* Nos. **25**, **31**, **32**.

Lagena foveolata Reuss (Pl. 16, fig. 15).

Lagena foveolata Reuss, 1862 (1863), p. 332, pl. 5, fig. 65.
Lagena No. 25 von Schlicht, 1870, p. 10, pl. 3, fig. 25.

Pl. 16, fig. 15. This is exceedingly delicate in its sculpture, and it is very likely the same as the one figured by Mr. Millett in his Malay Report, 1901, pl. 1, fig. 15. His drawing is much more satisfactory than mine. The test glistens. Three are marked on the Chart, but one of the three on the slide is *L. striata*, so the exact locality of the other two becomes uncertain. —*Locality :* Nos. **1, 20, 26.**

Lagena foveolata Reuss var. (Pl. 16, figs. 16, 17).

This is an interesting variation. About thirty-five are on the slide; all are apiculate and nearly all are in perfect condition. The cells are quite distinct and their bases show no sign of perforation.—*Locality :* Chiefly Nos. **17**, **29**, also very rarely at various stations.

Lagena foveolata Reuss var. nov. *spinipes* (Pl. 16, figs. 18–21).

In this variation some of the costae project at regular intervals round the base and also carry very narrow, minute, blunt spines as shown in the drawings. These spines appear to be tubular. In some of the specimens they are absent, but probably they have been broken off, as on a careful examination minute, loop-like orifices can be detected. Many of the tests have so much exogenous shell-growth filling up the cells that it is with difficulty the cross-bars can be detected, but on breaking open such a test, mounting it in Canada balsam, and viewing the inside concave surface by transmitted light, the cross-bars show quite distinctly.

Pl. 16, figs. 18, 20 must be taken as being more or less diagrammatic representations.—*Locality :* Chiefly Nos. **9**, **17**, **19** and odd examples from a few other stations.

Pl. 16, fig. 21. A solitary specimen, evidently a rotund form.

Lagena foveolata Reuss (?) var. nov. *paradoxa* (Pl. 16, figs. 22, 23).

The test is flask-shaped, always elongate, with a short neck, slightly thickened at the orifice. Fine costae run down the test.

The cells are formed by cross-bars between the costae, which are not so high as the costae, and are all filled with exogenous shell-growth. Nearly all the tests show signs of disintegration, and when this has taken place the shell-wall shows transparent, with rows of minute spines arranged in lines, as shown in fig. 23. I am unable to state whether these spines are tubular. In more than one case the whole of the outward part of the test has gone, leaving the inner shell bare, except for the spines.

The superstructure is thick, as can be seen in fig. 23. There are over fifty on the slide. The cross-bars can be detected in a few of the large tests only; but when a broken test is mounted in Canada balsam, and viewed on the inside, concave surface, by transmitted light, the cross-bars are quite distinct and are arranged in line and not alternately. The tests are opaque and of a pale cream colour. The opaqueness is probably due to age. The question naturally arises—is this a true *L. foveolata* and is all this shell-growth the result of age? Perhaps *L. seriato-granulosa* Reuss, 1870, p. 468, No. 16—Schlicht, 1870, pl. 38, fig. 20, is related to, or identical with, this form. Schlicht's illustration seems to show a change of the surface ornament close to the neck. Is this the beginning of the disintegration which is so common in my specimens? Schlicht's figure and its description are not sufficient for absolute identification. Brady puts this figure under *L. striatopunctata* in the *Challenger* Report.

Lagena lamellata sp. nov. (Pl. 16, figs. 24, 25).

This belongs to the class of Lagenae that have their walls compound. There are two large specimens on the slide, one of which is almost in perfect condition. The long neck has the spiral sculpture, and is normally straight. The colour is a pale cream. The surface of the test seems to be built up of thin flakes, arranged in an irregular manner, which, although rough, glisten to a certain extent. Damaged specimens show the compound shell-wall to be of extraordinary thickness. The outer, flaky surface appears to be held up by fine spines (tubular, I think), and the interstices partially filled with exogenous shell-growth.

The section, fig. 25, of part of a broken example from a *Penguin* station shows the relative widths of shell-wall and test. The shaded portion represents the exogenous shell-growth. Three tests are on the slide, but one of them does not belong to this species.—*Locality:* Nos. **20, 21.**

Note.—It is impossible to deal satisfactorily with the different forms of the compound-walled Lagenae unless good sections can be obtained. I am at present unable to undertake the work, partly from not wishing to sacrifice specimens, especially when very rare, and also from inability to use the very high-power lenses which are necessary for the small specimens. It is not difficult to grind down half the test, if you have specimens to spare for failures. Many of the tests, however, are exceedingly friable, and once in the Canada balsam and heated, I doubt if they would bear turning over, in order to procure thin sections. It will be understood that with the test only partly ground down, the illumination must be from above; a difficulty which I cannot overcome when using high-power lenses, no doubt owing to my technical ignorance. The following descriptions are given to the best of my ability.

Lagena hertwigiana Brady var. nov. *undulata* (Pl. 16, figs. 26–28).

There are about one hundred examples on the slide, and I believe them to be a variety of *L. hertwigiana.* The test is round in section, more or less ovate or pyriform in outline, with a long, delicate neck which broadens out a little at the orifice. The body of the test is covered with slight ridges, which give it a wavy appearance. There is a single row of perforations between the ridges. The wall is compound and appears to be cellular. Brady, in the *Challenger* Report, refers to a variety which has the perforations arranged in lines, as in *Nodosaria intercellularis,* but does not mention the ridges. The long neck is rather more delicate than represented in my drawings. The tests are opaque and of a light cream colour.—*Locality:* Chiefly Nos. **1 3, 7, 13, 17, 28.**

Pl. 16, fig. 28. This varies from above in having the perforations much closer together and the ridges even less raised. It is semi-transparent and very rare. On breaking one of the specimens a short, straight, entosolenian tube was revealed. The wall of the test appeared to be cellular.

Lagena pacifica sp. nov. (Pl. 16, fig. 29).

The test is ovate, elongate, and has a long, delicate neck. The surface, under a high power, appears to be marked all over with irregular depressions, and shines to a certain extent. The wall is compound, but I am at present unable to ascertain its exact nature. Very rare.—*Locality:* Nos. **1**, **22**, and a few other stations.

Lagena pannosa Millett.

Lagena pannosa Millett, 1901, p. 11, pl. 1, figs. 12–14.

There is only one example, and it is of the variety *L. pannosa* var., fig. 14. Mr. Millett states that in this variety "the disintegration is more irregular and the zones are not produced." The test is more globular than the one figured by Mr. Millett.—*Locality:* Exact locality uncertain.

Lagena spumosa Millett var. (Pl. 16, fig. 30).

Lagena spumosa Millett, 1901, p. 9, pl. 1, fig. 9.

Mr. Millett considers this to be a variety of his *L. spumosa*. It differs from the type in not having the "bird's-clawlike" process at the oral end, but simply a short, straight, transparent blunted point to the test, which is flattened at the base. The shell-wall is compound. The test is much more brittle than one would expect from its appearance.—*Locality:* It occurs rarely at twelve stations, but chiefly at No. **30**.

Lagena chasteri Millett (Pl. 16, fig. 31).

Lagena chasteri Millett, 1901, p. 11, pl. 1, fig. 11.

This occurs sparsely at a few stations. Some of the smaller examples are more slender than the one figured, and in these the neck and upper portion of the test are inclined to be bent a little to one side. The curious little "stopper" at the orifice is sometimes difficult to make out; Mr. Millett tells me it is characteristic of the species.—*Locality:* Exact localities uncertain.

Lagena chasteri Millett, var. (?) (Pl. 16, figs. 32–34).

These appear to me to be variations of the type. Some, at any rate, show the "stopper" at the orifice. The test is very finely pitted all over, and in certain conditions minute pores can be seen quite plainly, under a magnification of one hundred diameters.

Pl. 16, fig. 33. In this the surface is not so polished as in Pl. 16, fig. 32.

Pl. 16, fig. 34. The test is a good deal roughened, and the pores show much more plainly.

The specimens are placed under the above heading provisionally, until the exact nature of the shell-wall can be ascertained by sections. Rather rare.—*Locality:* Exact stations uncertain. Taking these and the type form together, they occur at various stations, including Nos. **20, 21.**

Lagena intermedia sp. nov. (Pl. 17, figs. 1–3).

There are thirty-one specimens brought together on the slide, eleven of which belong to these gatherings, and as they agree so well in their chief characteristics I have given them a specific name. Many of them agree with Brady's *Challenger* drawing, fig. 20, pl. 57, which he calls an intermediate form, resembling *L. crenata* and *L. semistriata.*

The specimens vary in contour, and are nearly all transparent. There is a ridge running round the base, and immediately above this is a series of grooves (more or less pointed at the top) encircling the lower part of the test. The entosolenian tube is straight. The base of the test is covered with an irregular, mesh-like set of partitions, much blocked up by shell-growth. The solid portion at the apex of the test, through which runs the pseudopodial passage, is characteristic of the species. Rare.—*Locality:* Nos. **28, 30, 32.** Solitary specimens at a few other stations.

Lagena sp. incert. (Pl. 17, figs. 4, 5).

There are nine specimens on the slide, one or two of which are in a very poor condition, and only three belong to these *Waterwitch* gatherings. I have figured the one that is in the best state. One or two of the set are a little compressed. The orifice is stellate, and the entosolenian tube is bent to one side. The body of the test is striate, except the upper part; a decorated collar runs round the base, and from this springs downwards what may have been the decorated wall of another chamber, but this is only surmise. The edge of this wall shows signs of fracture in all these specimens. There appears to have been an inner chamber, when the specimen was in perfect condition, but as this is fractured in all the examples found, one cannot be certain of its exact nature. The convex base apparently belongs to this inner chamber (?). The drawings will explain better than any written description. It may turn out to be a complex species of a new genus.—*Locality:* Nos. **3**, **17**, and one specimen (doubtful) at No. **29**.

Lagena sp. incert. (Pl. 17, fig. 6).

There are only two examples of this doubtful Lagena. The oval body of the test is slightly roughened, semi-transparent, and apiculate. I am not sure if the apiculate process is tubular. In both cases the long, tubular neck is fractured at the end, so we are left in ignorance as to the nature of the aperture. The *Oolina lanceolata*, Terquem, 1858, pl. 1, fig. 1, is the nearest in outline to my drawing that I have noticed.—*Locality:* No. **11**.

Lagena laevigata Reuss sp.

Fissurina laevigata Reuss, 1850, p. 366, pl. 46, fig. 1.

This common species is found at nearly all the stations, and the specimens vary greatly. Some are very large and others minute. A few are circular in outline and much compressed. The *Fissurina oblonga* Reuss, 1862 (1863), p. 339, pl. 7, fig. 89, is present, and also a form similar in outline, which has the mouth placed at one side and the entosolenian tube attached to the back of the test. Specimens occur which are much flattened and have very short necks.

Lagena laevigata Reuss sp. var. (Pl. 17, fig. 7).

This form of *L. laevigata*, with its curious orifice, appears to be allied to *L. millettii*, Chaster, 1892, p. 61, pl. 1, fig. 10. Most of them have a very small pimple at the base. It occurs at several stations.—*Locality:* Chiefly No. **19**.

Lagena laevigata Reuss sp. var. nov. *virgulata* (Pl. 17, fig. 8).

There are four small, narrow, opaque markings on the test, two on either face. They are placed rather below the middle, and I think they are sometimes just raised above the surface. The contour of the test varies both as to compression and length.

Entosolenian tube straight. Orifice oval. A few have the base rounded off, but others are more or less pointed.—*Locality :* No. **17** and various other stations.

Lagena acuta Reuss sp. (Pl. 17, fig. 9).

Fissurina acuta Reuss, 1862, p. 340, pl. 7, fig. 90.
F. apiculata, p. 339, pl. 6, fig. 85.

Again one has to deal with a great variation in form. Elongate examples like fig. 9 are very rare, and they are very slightly compressed. These correspond to the *F. apiculata* of Reuss. Small examples which are ovate, or pyriform, in outline, are common. These latter generally have the apiculate process very small.—*Locality :* Various.

Lagena acuta Reuss sp. var. nov. *virgulata* (Pl. 17, fig. 10).

The form is that of *Fissurina apiculata* Reuss, 1862, p. 6, fig. 85, and has the four curious markings, two on either face, referred to before under *L. laevigata* var. The body of the test becomes more compressed as it approaches the orifice, which is fissurine and almost closed.—*Locality :* It occurs at a good many stations. Five are marked on the Chart as being found at No. **29**.

Lagena acuta Reuss sp. var. (Pl. 17, fig. 11).

I think this may be treated as a variety of *L. acuta*. The test is only slightly compressed, and when viewed endways, looking down on the orifice, it has rather a square appearance, caused no doubt by the three lines of perforations being situated at the four corners, so to speak. A few have the base rounded, but the others are more or less pointed. The tube is short and straight. I cannot make out the exact nature of the orifice. It is very minute and seems to be circular. As a rule, the perforations are confined to three lines. Nineteen found.—*Locality :* Nos. **1**, **7**, **14**, and a few others.

Lagena lucida Williamson sp. (Pl. 17, figs. 12–14).

Entosolenia marginata var. *lucida* Williamson, 1848, p. 17, pl. 2, fig. 17.

This pretty little foraminifer is found at a few stations, but is always very rare, though typical. Pl. 17, fig. 12, represents a circular form and is inclined to be bluntly carinate. Three only occur.—*Locality :* Uncertain.

Pl. 17, fig. 13 is circular in section and is probably a variation of the trifacial form, which generally has the sides more or less flattened. Four occur, one of which is much more globular than the one selected for illustration.—*Locality:* Nos. **1**, **3**, **18**, **29**.

Pl. 17, fig. 14. This appears to be *L. lucida* in a spinous condition, rather than *L. staphyllearia* in a *lucida* condition. Only one found.—*Locality :* No. **29**.

There is also another very similar to the above, in which the lower half of the keel splits and becomes triple. The central one is serrated.—*Locality :* No. **23**.

Lagena multicosta Karrer sp.

Fissurina multicosta Karrer, 1877, p. 379, pl. 16*b*, fig. 20.
Fissurina bouei, *Ibid.* p. 378, pl. 16*b*, fig. 19.

There are a few very small examples of this species and they are mixed up with *L. costata* on the slide, so that the exact localities cannot be given.

Lagena fasciata Egger sp. (Pl. 17, fig. 15).

Oolina fasciata Egger, 1857, p. 270, pl. 5, figs. 12–15.

The type form is very rare.

Pl. 17, fig. 15. This is the *L. annectens* Burrows and Holland, 1895, p. 203, pl. 7, fig. 11. It is very small, beautifully transparent, and the tube is short and straight. The examples vary in form from globular to moderately compressed. Very numerous.—*Locality :* They were nearly all found at Nos. **8**, **9**, **11**.

Lagena fasciata Egger sp. var. nov. *spinosa* (Pl. 17, figs. 16, 17).

There are a good number of this interesting form. In the larger examples the curved bands are generally distinctly raised. Sometimes, especially in the smaller ones, the curved bands are little more than fine, opaque lines. The basal spines are well developed. The aperture is long, curved and almost closed, and I think is composed of a series of fine pores. The entosolenian tube varies in length, but is always straight. The edge of the test is sometimes flattened. These specimens might, with equal propriety, be regarded as a decorated form of *L. staphyllearia.*—*Locality:* It occurs at seventeen localities, chiefly Nos. **1**, **3**, **9**, **17**, **18**, **29**, **32**. Pl. 17, fig. 16 is drawn from the largest specimen.

Lagena fasciata Egger sp. var. *carinata* Sidebottom (Pl. 17, fig. 18).

Lagena fasciata Egger sp. var. *carinata* Sidebottom, 1906, *Mem. Pro. Lit. Phil. Soc. Manchester*, p. 7, pl. 1, fig. 17.

The test is compressed, carinate and apiculate. The curved bands on both faces are extremely fine and perhaps just raised above the surface. There seems to be no reason why it should not be brought under the above heading, although in the Delos examples the curved bands are broad and scooped out, the test little compressed, the keel not so prominent, and the apiculate process not present. It occurs at many stations.—*Locality:* Chiefly Nos. **18**, **19**.

Lagena staphyllearia Schwager sp. (Pl. 17, figs. 19–24).

Fissurina staphyllearia Schwager, 1866, p. 209, pl. 5, fig. 24.

Both the carinate and non-carinate forms are present, but the carinate is far more frequent. Sometimes there are only a couple of spines connected by a small keel, at others simply a keel, which is dentate.

Pl. 17, fig. 19. This form varies little, and occurs only at a few stations.—*Locality:* Chiefly at Nos. **9**, **11**, where it is common.

Pl. 17, fig. 20 has the orifice to one side and is hooded. The tube is attached to the back of the test.—*Locality:* Various stations, chiefly at No. **32**. Always rare.

Pl. 17, fig. 21. In this variety the keel is carried right up to the orifice, which is a narrow oval. In some of the specimens the two side spines are not placed quite so high up as in the one selected for illustration. The orifice is fissurine. This form appears to be closely allied to *Fissurina tricuspidata* Reuss, 1870, p. 470; von Schlicht, 1870, pl. 5, figs. 16–18.—*Locality:* Nos. **3**, **6**, **7**, **24**. Always very rare.

Pl. 17, figs. 22, 23. These are very small, and may perhaps be a weak form of the compressed variety named by Brady *L. longispina* in the *Challenger* Report. I cannot, however, see my way to separate them from *L. staphyllearia.* The tube is straight.—*Locality:* Nos. **1, 3, 6, 7, 9, 14, 15, 17, 26.** Always extremely rare.

Pl. 17, fig. 24. Mr. Millett, in his remarks on *L. marginata* var. *seminiformis*, 1901, p. 620, refers to the tendency of *L. marginata* and its allies to duplicate the marginal keel. This is a case in point, the keel splitting on either side of the test as it approaches the base. The two longest spines are situated just at the splitting point, and generally there are two rows of smaller spines on the base of the test, between the keels. The tube is attached to one face of the test, and the orifice is fissurine. Rather rare.—*Locality:* No. **19.**

With the above are three tests that have a comparatively thick keel, which is thicker at its outer edge than at its junction with the body. This causes the latter to appear as if it were encircled by a fine, dark ring—a pretty effect. The keel splits at the base just sufficiently to admit of the spines being placed between. The tests are circular in outline and their sides convex.—*Locality:* One at No. **19,** the other two uncertain.

Lagena staphyllearia Schwager var. nov. *quadricarinata* (Pl. 21, fig. 16).

Test very slightly compressed, almost circular in outline. Internal tube attached. Orifice a narrow slit. The carina at the sides is very much more developed than the one that cuts it at right angles through the centre of the base.—*Locality:* Eight occur at No. **1,** two at No. **3,** and odd specimens at Nos. **14, 29, 32.**

Lagena unguiculata Brady (Pl. 17, fig. 25).

Lagena unguiculata Brady, 1881, *Quart. Journ. Micr. Sci.*, vol. 21, N.S., p. 61.
Lagena unguiculata Brady, 1884, p. 474, pl. 59, fig. 12.

Brady admits that this differs little from *L. staphyllearia,* and the curved teeth he refers to are not confined to this variety. All the tests in these gatherings have the lower part of the body roughened and opaque, as shown in the drawing. The oral end is sharp and the tube short and straight.—*Locality:* At No. **1,** eight occur; at No. **23,** one; at No. **24,** two; and one at Nos. **25, 26, 27**: fourteen in all.

Lagena quadrata Williamson sp. (Pl. 17, figs. 26–28).

Entosolenia marginata var. *quadrata* Williamson, 1858, p. 11, pl. 1, fig. 27.

This is only occasionally met with in the collection, but several variations are of interest. Both the form with the rounded edge and that which is slightly carinate occur.—*Localities :* Various.

The partially carinate form, similar to the *Challenger* figure, pl. 59, fig. 16, is frequent at locality No. **19**, and very rare at three other stations.

Pl. 17, fig. 26. There are only three of this curiously hooded variety. The test is slightly curved and the tube is attached to the back. Except for the bending of the test it is almost identical with Balkwill and Millett's drawing, 1884, pl. 1, fig. 11. —*Locality :* Exact stations uncertain.

Pl. 17, fig. 27. The two spines, one at either side of the orifice, appear to be round, and not flattened, as one would expect. Five examples are in the "quadrate" condition, and three others have the sides of the test slightly convex and are not so elongate.—*Locality :* Five found at No. **11**, two at No. **13**, one at No. **18**.

Pl. 17, fig. 28. A single specimen only occurs, having a well-marked keel at each end of the test. The orifice is placed at the junction of the keel with the body.—*Locality :* No. **3**.

Lagena marginata Walker and Boys (Pl. 17, figs. 29–31, and Pl. 18, figs. 1–3).

"*Serpula* (*Lagena*) *marginata*" Walker and Boys, 1784, p. 2, pl. 1, fig. 7.

This species is splendidly represented in these gatherings. There is great variation both in size and shape, and also in the development of the carina, which in many examples completely encircles the body of the test and in others is confined to the base. Intermediate forms occur. In a few cases the body of the test, as well as the carina, is apiculate.

The entosolenian tube is generally attached to one face of the test, but in some instances it is short and straight. The orifice likewise varies in character and position. The body is frequently decorated, in various ways, as in *L. orbignyana*. One or two examples are very near to *Fissurina bicaudata* Seguenza, 1862, pl. 2, fig. 16. The following are interesting variations:

Pl. 17, fig. 29. There are only two of these. Four others have the body of the test more elongate. I have unfortunately broken the one from which the illustration was drawn.—*Locality:* Exact stations uncertain.

Pl. 17, fig. 30. In this elegant form the keel is continuous round the body. In nearly all cases the carina is bent backwards—that is, if one considers the orifice as opening out on the face of the test. The entosolenian tube is attached to the back of the test, which is much more convex than the face. It may be related to *L. marginata* Walker and Jacob var. *inaequilateralis* Wright, 1884–5, app. 1886, pl. 26, fig. 10, but the keel is much more developed, and the orifice is a simple opening and of an entirely different character.—*Locality:* Chiefly at Nos. **11, 14.**

Note.—A curious feature of the entosolenian tube in this variety, which I have not noticed before, is that it is only half a tube, if one may use the expression, with its edges attached to the wall of the test, part of the wall thus helping to form the tube. This peculiarity is best seen when viewed from the back. My attention was drawn to this feature by one of the specimens having the internal opening of its tube of specially large size and arched instead of circular. On further examination it was accounted for in the way I have explained above. I do not know if this peculiarity has been noticed before, but after examining further I find it is not limited to this particular variety.

Pl. 17, fig. 31. An elongate form. Tube attached. Orifice compressed, the front edge lower than the back.—*Locality:* Nos. **18, 19,** and a few others. Always rare.

Pl. 18, fig. 1. This foraminifer appears to be closely allied to the *L. seguenziana* Fornasini, 1886, pl. 8, figs. 1–8. Unless it is viewed edgeways the exact contour of the test may easily be overlooked. Only one occurs.—*Locality:* Probably No. **1.**

Pl. 18, fig. 2. This is an exceedingly large specimen. The keel has the appearance of being composed of two layers, but I believe this is not so. The central body is highly convex and is badly fractured on one side. One only found.—*Locality:* No. **28.**

Pl. 18, fig. 3. The test is a good deal compressed and has a broad, semi-opaque band running round it on either side, adjoining the carina. The carina is a true one and of clearer shell-substance than the body of the test. On the Chart, three specimens are marked (not necessarily alike), but there is only one on the slide.—*Locality:* Exact station uncertain; either No. **2** or No. **11**.

Lagena marginata Walker and Boys, var. (Pl. 18, figs. 4, 5).

There are a good number of these forms and no line of demarcation can be drawn between them. Nearly all of them have four costae running up the neck, two on either side. Those in which these costae are absent are similar to the *Challenger* drawing, pl. 59, fig. 6, which, Brady states, "might, with equal propriety, be treated as a mucronate example of *L. marginata*," and such I take them to be. Several of the specimens might be looked upon as the apiculate form of *L. marginata* var. *semimarginata* Reuss.—*Locality:* Chiefly No. **29**.

Lagena marginata Walker and Boys var. *catenulosa* Chapman (Pl. 18, fig. 6).

Lagena marginata var. *catenulosa* Chapman, 1895, p. 28, pl. 1, fig. 5.

After drawing this solitary specimen, I was unfortunate enough to break it. There was a good deal of exogenous shell-growth, which interfered with the definition of the chain-like borders which encircle the body of the test, referred to by Chapman. Fortunately, in another set of soundings from the S.W. Pacific, there are four fine examples which I shall hope to figure in the future. The outer circle of chain-work (well raised up), if not the inner one, is on the carina.—*Locality:* Exact station uncertain.

Lagena marginata Walker and Boys var. nov. *umbonata* (Pl. 18, fig. 7).

Test compressed and surrounded with a well-developed carina. A few costae, starting close to the orifice, radiate downwards to the upper part of the body of the test, on both faces. A well-raised "boss," generally ribbed, is placed near to the base on both sides, and free of the keel. Internal tube short and straight. The oral end is oval and the actual orifice a very narrow slit. Twelve examples occur.—*Locality:* Nos. **3**, **13**, **17**.

Lagena marginata Walker and Boys var. nov. *raricostata* (Pl. 18, figs. 8, 9).

Pl. 18, fig. 8. This looks very like the form figured by Rymer Jones, 1872, p. 52, pl. 19, fig. 19, under the name *Lagena vulgaris* Williamson var. *striata* Montagu, the only apparent difference being that my examples are compressed, and his specimen, I presume, was round in section. The test is slightly compressed near the base, and gradually becomes more so until the orifice, which is fissurine, is reached, at which point the compression is well marked. The one figured has only two costae on each face of the test; in the others a central costa is added, but is not so well marked. The carina is well developed. Six occur, one of which is very short, and is an intermediate form between this and fig. 9.—*Locality:* It occurs very rarely at Nos. **1, 2, 17, 23.**

Pl. 18, fig. 9. Test compressed, carinate. The two chief costae start from the orifice, on both sides of the test, and bend round the convex surfaces of the body of the test, spreading out a little as they approach its base. There are two curved, subsidiary costae on either side of the main ones, and also a straight, short one between them. The keel is slightly pointed at the base, and the internal tube is short and straight. I think this may be taken as a variant of the form last described. Twenty are on the slide.—*Locality:* Chiefly Nos. **18, 19.**

Lagena marginata Walker and Boys var. nov. *striolata* (Pl. 18, figs. 10, 11).

Test compressed, carinate, many riblets running lengthwise on both faces of the test. The orifice is phialine, and varies in the amount of its compression. Nearly all the examples have the spaces between the costae, or riblets, more or less filled with shell-growth, which is of a light yellow colour. The specimens vary in size and the riblets in number, these latter being sometimes extremely numerous. There are over fifty on the slide.—*Locality:* Chiefly Nos. **17, 19, 28.**

Pl. 18, fig. 11. There are four specimens, although not typical, which I think may be placed with the above. The shell is not so much compressed and the costae become weak as they approach the upper part of the test. The keel is better developed. The one figured is rather broader at the shoulders than the others, but I chose it for illustration as it was in the best condition. The tube is short and straight. These forms may be allied to *Lagena marginato-radiata* Seguenza, 1880, p. 332, pl. 17, fig. 35.

Lagena marginata Walker and Boys var. nov. *elegans* (Pl. 18, fig. 12).

Test compressed, carinate. The body of the test is covered with fine, broken-up striae, and is apiculate. The carina joins on to the apiculate process. This is a very neat form, and two examples only were found.—*Locality:* No. **26**.

Lagena marginata Walker and Boys var. nov. *retrocostata* (Pl. 18, fig. 13).

Test compressed, carinate, with irregular costae running across each face, one (or two) of which curves back before it reaches the opposite side. There is a well-developed ring at the base. The orifice is small and circular, or nearly so. Four only occur. The costae are not always arranged as in the drawing, but they have the same characteristics, and there is no mistaking the species when once seen.—*Locality:* One was found at No. **8**. The other stations are uncertain.

Lagena marginata Walker and Boys var. nov. *armata* (Pl. 18, fig. 14).

Test compressed, carinate. The orifice, which is circular and outspread, is slightly bent forwards. On both faces of the shell are two dimples, placed low down and close to the keel. In the centre of each of these dimples is a small "boss." There was only a single example of this interesting variety found, and I have either lost it or misplaced it on the slide.—*Locality:* No. **9**.

Lagena marginata Walker and Boys var. nov. *homunculus* (Pl. 18, fig. 15).

Test compressed, carinate. Aperture fissurine, with a pointed spine curving downwards on either side. Low down on each side of the test a short spine projects, and between these at the base are two flattened processes, shaped like feet with the toes turned inwards. In several instances another spine, but pointed, is placed between the feet. This seems to be a variety of *L. marginata*, in which the keel is broken up in an extraordinary manner.

I think Nature must have been in a comical mood when she thought of this design. It at once suggests a caricature of the human figure. There are fourteen on the slide, and they vary little from the one figured.—*Locality:* Twelve were found at No. **11**, and one each at Nos. **8** and **13**.

Lagena marginata Walker and Boys var. *semimarginata* Reuss.

Lagena No. 64 von Schlicht, 1870, p. 11, pl. 4, figs. 4–6; and *No. 65*, p. 11, pl. 4, figs. 10–12.

Lagena marginata var. *semimarginata* Reuss, 1870, p. 468.

The form as figured by Mr. Millett, 1901, p. 14, fig. 1, in his Malay Report is present, but is rare. That with the keel or wing, confined to the upper portion of the test, is extremely rare.—*Locality:* Exact stations uncertain.

Note.—See also remarks regarding Pl. 18, fig. 5.

Lagena marginata Walker and Boys var. *seminiformis* Schwager (Pl. 18, figs. 16–21).

Miliola stiligera Ehrenberg (?), 1854, pl. 31, fig. 6.

Lagena seminiformis Schwager, 1866, p. 208, pl. 5, fig. 21.

The fine examples of this variety of *L. marginata*, as figured in the *Challenger* Report, do not occur in these soundings, but the examples are interesting.

Pl. 18, fig. 16. This is an elongate variety. All have a short spine at the centre of the base. The internal tube, when present, is short and attached to the face of the test.—*Locality:* Twenty-seven occur at No. **11**. It is very rare at two or three other stations. One was found in the trigonal state.

Pl. 18, fig. 17. This only differs from the preceding in having a curious flange-like process at the base, on both faces of the test.—*Locality:* Nos. **21**, **23**. Very rare.

Pl. 18, fig. 18. This comes nearest to Schwager's figure. The tube is attached.—*Locality:* Nos. **1**, **2**, **18**, and several other stations. Rare.

Pl. 18, fig. 19. It is evident that this bears a strong resemblance to the "Crag" illustration, Jones, 1895, p. 200, pl. 7, fig. 10, assigned to *L. seminiformis* Schwager. The orifice is funnel-shaped and slightly bent forwards. Tube attached.—*Locality:* No. **13**. Only two found.

Pl. 18, fig. 20. The keel in this variation almost, but not quite, loses itself at the sides of the test. The tube is attached and the aperture compressed.—*Locality:* No. **11.** Rare.

Pl. 18, fig. 21. The peculiarity in this case is that the two projections at the base close in upon a small, central spine, the effect under the microscope being that of two loops formed by a bright line.—*Locality:* No. **11.** Only two or three are in this condition.

Lagena marginato-perforata Seguenza.

Lagena marginato-perforata Seguenza, 1880, p. 332, pl. 17, fig. 34.

These vary a good deal in their contour. A few only have the keel fairly well developed.—*Locality:* Very rare at a few stations.

Another set is more elongate, and has the keel more developed at the base than at the sides. In some cases the centre of the test is free from markings.—*Locality:* It occurs at a good many stations, but is always rare.

Lagena radiato-marginata Parker and Jones.

Lagena radiato-marginata Parker and Jones, 1865, p. 355, pl. 18, figs. *3a*, *3b*.

There are thirty-two examples of this beautiful Lagena on the slide, and they are in perfect condition.—*Locality:* It occurs at various stations, but chiefly at Nos. **20, 21, 22.**

Lagena wrightiana Brady.

Lagena wrightiana Brady, *Quart. Journ. Micr. Sci.* vol. 21, 1881, p. 62.

Lagena wrightiana Brady, 1884, p. 482, pl. 61, figs. 6, 7.

Two or three only were found. They are small and are not in very good condition.—*Locality:* Uncertain.

Lagena lagenoides Williamson sp. (Pl. 18, figs. 22–29 and Pl. 19, figs. 1–3).

Entosolenia marginata (Walker and Boys) var. *lagenoides* Williamson, 1858, p. 11, pl. 1, figs. 25, 26.

There are a large number of the type and its variations. Both the long and short form, figured by Williamson, are present. One set has the tube straight, and another has it attached. Sometimes the tube is absent.

Pl. 18, fig. 22. This is the same as the one figured by Mr. Millett, 1901, p. 623, pl. 14, fig. 8, of which there are numerous examples. Mixed up with them is a rather smaller form, the wing of which is not so broad, but stouter, and therefore not so liable to become damaged. There is one specimen in the trigonal condition, found at No. **11.**—*Locality:* Chiefly Nos. **8, 11, 19, 22.**

Pl. 18, fig. 23. The keel, in this instance, splits half-way down the edge of the test and the space is filled with shell-growth or debris, from which in a few instances fine, hair-like spines project. This shell-growth, or débris, is not always confined to the split carina, but often spreads over the lower half of the test, and the delicate spines also appear. I presume that if the specimens were in perfect condition these spines would be very numerous. Tube attached.—*Locality:* Chiefly Nos. **1, 21, 29.**

Pl. 18, fig. 24. It may be that the carina has partially broken away, leaving the tubular portion intact. There are only two in this condition, the one not figured showing even less of the carina. The entosolenian tube is short and straight. —*Locality:* Nos. **11, 19.**

Pl. 18, fig. 25. The cellular carina is narrow, but comparatively stout, and is absent for a short distance on each side of the test. The internal tube is short and straight. Twenty-one are on the slide.—*Locality:* Chiefly at No. **11.** Very rare at Nos. **8, 12, 19.**

Pl. 18, fig. 26. The test is curiously contorted, especially the lower half of the carina, one side of which dips down suddenly at the base, thus causing the lower halves of the carina to lie in different planes. The keel itself seems inclined to be concave or convex, according as the edge is twisted upwards or downwards. It is a very delicate foraminifer and many of the specimens are fractured. The tube is attached. Seventeen occur.—*Locality:* Chiefly Nos. **11, 19.**

Pl. 18, fig. 27. There are five examples of this circular and entosolenian variety. The tube is curled back upon itself. The test is fairly well compressed.—*Locality:* Four were found at No. **19.**

On the same square are also five elongate specimens, but the cellular rim is of a different character and the internal tube is long and straight. The outline is that of an elongate *L. laevigata.*

Pl. 18, fig. 28. In this case very nearly the whole carina is double, and just wide enough to allow the opening of the cellular passages to be distinctly seen. The tube is twisted and turned to one side. Sixteen found.—*Locality:* Chiefly No. **19**.

Pl. 18, fig. 29. Two specimens only occur. In the one figured, the band at the edge is practically flush with the body of the test, in the other case it slightly projects.—*Locality:* Nos. **4**, **13**.

There is a third test on the slide, in which the orifice is more produced and the carina is more distinctly double, the space being filled with shell-growth or granulated matter. In size and contour it is the same as the above.—*Locality:* No. **32**.

Pl. 19, fig. 1. Test a little compressed. Around its edge are two ridges, connected at regular intervals by cross-bars. In the centre, between the cross-bars, there is a circular depression, which is not the orifice of a large pore, though very likely the base of each depression is porous. Orifice circular. This solitary example might with almost equal propriety have been placed under *L. bicarinata.*—*Locality:* No. 30.

Pl. 19, fig. 2. The test is not much compressed. The entosolenian tube is straight.—*Locality:* Uncertain. Very rare.

Pl. 19, fig. 3. This is a very much compressed variety, and has a double row of pores showing round the edge of the test; these are separated by a ridge, so that with the two lateral carinae the test in a feeble way resembles *L. orbignyana.*

Mr. Morton, 1897, pl. 1, fig. 5, refers to numerous specimens found in marine clay, Maine, America, which appear to be much in the same condition.

Fig. 3*b* gives a fair representation of the edge of the test, as far as I can make it out.—*Locality:* No. **8**. Only one occurs.

Lagena lagenoides Williamson var. *tenuistriata* Brady (Pl. 19, figs. 4, 5).

Lagena tubulifera var. *tenuistriata* Brady, 1881, *Quart. Journ. Micr. Sci.*, vol. 21, N.S., p. 61.

Lagena lagenoides Williamson var. *tenuistriata* Brady, 1884, p. 479, pl. 60, figs. 11, 15, 16.

There is a large number of this handsome form, and it agrees best with the *Challenger* figure, pl. 60, fig. 11. Brady writes of the markings as "striae," and in most of these specimens they consist of distinct "costae." There is a tendency in the central costae to run up the neck, and if they were a little more developed we should have the *L. quadralata* Brady. They are marked as occurring at fourteen stations.—*Locality:* Chiefly Nos. **1, 3, 11, 17, 31.**

Pl. 19, fig. 5. This is the trifacial form, of which only two specimens were found.

Lagena formosa Schwager (Pl. 19, figs. 6–9).

Lagena formosa (pars) Schwager, 1866, p. 206, pl. 4, fig. 19.
Lagena formosa (Schwager) Brady, 1884, p. 480, pl. 60, figs. 10, 18–20.

This seems to be an unsatisfactory species, and as Mr. Millett remarks in his Malay Report, 1901, p. 624: "This species seems to differ from *L. lagenoides* only in the raised border which immediately surrounds the body of the test." In these gatherings there are over forty-five examples that agree fairly well with the *Challenger* figures, pl. 60, figs. 18–20, except that I cannot make out any punctate ornament on the raised border which surrounds the body of the test. When this does appear to be present, it seems to me that it is caused by the tubuli in the wing being seen through the raised border, which is transparent. In some of the examples the raised border is absent, except just at the base, and in others it is very feeble. The wing often splits as it approaches the base of the test, as shown in Pl. 19, fig. 6.—*Locality:* Chiefly Nos. **1, 3, 11, 17.**

Note.—The shape of the tests and their general appearance are so near to Brady's *Challenger* figures, that in spite of the absence of the punctate ornament they must be placed under *L. formosa.*

Pl. 19, fig. 7. Two specimens only, but they are large. They differ little from the preceding.

Pl. 19, fig. 8. In these the raised border is very slight, but is decorated as shown in the figure. The tube, when present, is attached. *Locality:* Over thirty were found at No. **11.** Very rare at several other stations.

Pl. 19, fig. 9. Test compressed. The wing that surrounds the body of the test gradually becomes less as it approaches the apiculate process at the base. The tubuli are confined to the raised border, and set so close to each other that they give a frosted appearance to it. There is a space between the border and the wing. In a few cases the wing, or keel, dies away almost as soon as it reaches the body of the test. Over forty are on the slide. *Locality :* Chiefly Nos. **3, 7, 18, 26, 28, 30**.

Lagena formosa Schwager var. *comata* Brady (Pl. 19, figs. 10–12).

Lagena formosa var. *comata* Brady, 1884, p. 480, pl. 60, fig. 22.

Pl. 19, fig. 10. Bearing in mind the form of the test and the raised border, I think this may be looked upon as a weak form of *L. formosa* (Schwager) var *comata* Brady. There is a narrow space between the border and the keel, which often either splits towards the base or ends in tubular projections. The body is striated. All the tests are imperfect and the split wings are clogged with shell-growth. *Locality :* Chiefly Nos. **1, 2, 17, 18**. Frequent.

Pl. 19, fig. 11. The lower end of the test is only slightly compressed, but the compression becomes more marked as the orifice is approached. The keel, commencing at the orifice, becomes less pronounced as it proceeds towards the base. Surrounding the body of the test, on either face and at a short distance from the keel, is a raised border, perforated by tubuli. On both edges of the test there are two costae, one on either side of the keel, between it and the border. The tests are small and a good deal of shell-growth, or debris, is found on most of the examples between the costae, which interferes with their definition.—*Locality :* Nos. **3, 17, 19**. Rare.

Pl. 19, fig. 12. This appears to be the trigonal form of the above, and occurs more frequently and at numerous stations.—*Locality :* Nos. **1, 3, 9, 11, 19, 26**, and a few other stations.

Lagena orbignyana Seguenza sp.

Entosolenia marginata (pars) Williamson, 1858, p. 10, pl. 1, figs. 19, 20.

Fissurina orbignyana Seguenza, 1862, p. 66, pl. 2, figs. 25, 26.

This occurs in many forms, typical and otherwise, and at various stations.

Lagena orbignyana Seguenza, var. (Pl. 19, fig. 13).

There are about twenty on the slide and they are in the apiculate condition. In most cases, if not all, the apiculate process is tubular. The entosolenian tube is straight. In a few instances the orifice does not protrude, and in these cases the entosolenian tube is attached. *Locality:* Chiefly at No. **11**.

Lagena orbignyana Seguenza, var. (Pl. 19, fig. 14).

After very careful examination I believe this minute foraminifer to be feebly tricarinate. There seem to be traces of a central ridge. Both faces of the test are highly convex, and the basal spines are placed between the keels. It may be related to Mr. Millett's *L. orbignyana* var. *calcar* Millett, Malay Report, 1901, p. 626, pl. 14, fig. 18.—*Locality:* Uncertain.

Lagena orbignyana Seguenza var. nov. *coronata* (Pl. 6, fig. 15).

This beautiful specimen has a broad, opaque band encircling each face of the test, the central portion of the test being transparent. The chief keel is dentate at the base. One only occurs. —*Locality:* No. **23**.

Lagena orbignyana Seguenza var. *lacunata* Burrows and Holland (Pl. 19, figs. 16–18).

Lagena lacunata (Burrows and Holland) Jones, 1895, p. 205, pl. 7, fig. 12.

Pl. 19, fig. 16. In these specimens the depressions are well marked and their boundaries form an irregular, mesh-like pattern. The effect is very pretty, as the depressions are opaque and the mesh-work shows up dark. One specimen is in the trifacial condition.—*Locality:* Chiefly Nos. **1**, **2**, **19**. Frequent.

Pl. 19, figs. 17, 18. The markings are minute and in some cases seem to be the orifices of pores, but of this I am not certain. In the majority of cases the keels are feebly developed, and sometimes, as in fig. 18, they are hardly discernible. The entosolenian tube is straight.—*Locality:* Chiefly Nos. **19**, **21**.

Lagena orbignyana Seguenza var. nov. *stellata* (Pl. 19, fig. 19).

Test oval, tricarinate and apiculate. Orifice slightly protruding. Central portion of both faces of the test pitted and the remaining portion decorated with a series of fine arches. Entosolenian tube short and straight. The decoration is more delicate than shown in the illustration. Only a single example found. —*Locality:* No. **13.**

Lagena orbignyana Seguenza var. nov. *curvicostata* (Pl. 19, fig. 20).

The two side keels are recurved at the base and join the central keel, which is well developed. The decoration is a series of grooves, which are mostly bent as they approach the border and are sometimes irregular. Only one occurs.—*Locality:* Uncertain.

Lagena orbignyana Seguenza var. *walleriana* Wright (Pl. 19, fig. 21).

Lagena orbignyana var. *walleriana* Wright, 1886, *Proc. R. Irish Acad.*, ser. 2, vol. 4, p. 611, and 1891, p. 481, pl. 20, fig. 8.

The central "boss" is very slightly raised and surrounded by a ring. In some of the examples the "boss" is absent, but the ring is present. Over thirty are on the slide, and they are marked as occurring at eight stations.—*Locality:* Chiefly Nos. **8, 13, 19.**

Lagena orbignyana Seguenza var. nov. *unicostata* (Pl. 19, fig. 22).

In this variety there is a single costa running lengthwise down the centre of each face of the test. Ten occur and one is in the trifacial condition. In two other examples the costa is absent. —*Locality:* Three occur at No. **18.**

Lagena orbignyana Seguenza var. nov. *concentrica* (Pl. 19, fig. 23).

Test compressed. Central keel well developed. This solitary specimen has the faces of the test decorated with arched costae, as shown in the drawing, but they are more delicate than indicated.—*Locality:* Uncertain.

Lagena orbignyana Seguenza var. *pulchella* Brady. (Pl. 19, fig. 24).

Lagena pulchella Brady, 1866, *Rept. Brit. Assoc.* (Nottingham), p. 70.

Lagena pulchella Brady, *Annals and Mag. Nat. Hist.*, 1870, p. 294, pl. 12, fig. 1.

The type form is present, but is very rare.

Pl. 19, fig. 24. This is a pretty, elongate variety. The markings are very delicate and irregular. About nine occur.—*Locality:* Chiefly No. **2**.

Lagena orbignyana Seguenza var. *clathrata* Brady.

Lagena clathrata Brady, 1884, p. 485, pl. 60, fig. 4.

The bold form, as figured in the *Challenger* Report, is not present, but many examples occur in which the keels are rather feebly developed. The costae are more numerous than in the type. Several specimens are in the trifacial condition.—*Locality:* Chiefly Nos. **1, 17, 18, 19**.

Lagena orbignyana Seguenza var. *variabilis* Wright.

Lagena orbignyana var. *variabilis* Wright, 1890, p. 482, pl. 20, fig. 9.

The type form is present, but is extremely rare.—*Locality:* Uncertain.

Small examples occur which are oval in outline, and, as in the type, the costae are confined to the lower part of the test. The trifacial form is present.—*Locality:* Chiefly Nos. **18, 19**. Rather rare.

Lagena orbignyana Seguenza (?) (Pl. 21, fig. 15).

The single keel, starting at the orifice, splits part way down, on both sides of the test, into three well-developed carinae, which are more or less serrated at the base.—*Locality:* Occurs at a good many stations, including Nos. **13, 17, 26**.

Lagena bicarinata Terquem sp. (Pl. 19, figs. 25–27, and Pl. 20, fig. 1).

Fissurina bicarinata Terquem, 1882, p. 31, pl. 1 (9), fig. 24.

Pl. 19, fig. 25. This occurs in two forms; frequently with no central ring, and very rarely with two, as in the type form. The two forms are mixed on the slide. Tube straight.—*Locality:* Chiefly Nos. **8, 11, 12, 19.**

Pl. 19, fig. 26. A few are in a spinous condition, as shown in the drawing. When these spines are present there is generally a certain amount of exogenous shell-growth. These specimens are mixed, on the slide, with the two above named.

Pl. 19, fig. 27. In this the keels are feebly developed and wide apart. The entosolenian tube is long, often sinuous, and is attached to the face of the test.—*Locality:* It occurs at Nos. **1, 17, 18, 19**, and a few other stations, but is always rare.

Other forms occur, some very large and others small, some with long necks and some without any.

Pl. 20, fig. 1. The body of the test is much more compressed near the commencement of the neck than at the base, and the side wings which spring from the neck split and join the ridges that surround the body.—*Locality:* No. **19.** It is rare.

Lagena bicarinata Terquem var. nov. *imbricata* (Pl. 20, fig. 2).

Projecting from the two ridges that surround the body of the test on both faces is a series of short cross-bars that reaches half-way across the edge of the test. Generally these cross-bars are placed alternately and the spaces between are filled with shell-growth. The internal tube is attached. Only one found. On the same square is another solitary specimen, similar, except that between the ridges surrounding the body there are two extra ridges, and the cross-bars appear to be confined to the outer portion.—*Locality:* The two specimens are marked from No. **19** and No. **20**, but to which station each belongs is uncertain.

Lagena bicarinata Terquem var. nov. *horrida* (Pl. 20, fig. 3).

This fine specimen has the keels set well apart, right up to the edge of the orifice. The space between them is filled with shell-growth, from which project innumerable fine spines.—*Locality:* No. **19.**

On the same square are several very similar specimens, but the double carina is confined to the body of the test; there are no spines showing, and the keels are not placed so far apart.

Lagena auriculata Brady (Pl. 20, figs. 4–14).

Lagena auriculata Brady, 1881, *Quart. Journ. Micr. Sci.*, vol. 21, N.S., p. 61.

Lagena auriculata Brady, 1884, p. 487, pl. 60, figs. 29, 33 and 31 (?).

In these soundings this species is subject to extraordinary variation. The specimens form a most interesting series, eight of which resemble Brady's *Challenger* illustration, pl. 60, fig. 33.—*Locality:* No. **29.**

Pl. 20, fig. 4. This is the same as the above, excepting that there is a flange projecting at the base, on both sides of the test.—*Locality:* No. **19.** Only one occurs.

Pl. 20, fig. 5. In this the body is elongate, with a long neck, and the loop-shaped, laminar process on either side of the base is lengthened and narrowed, until it becomes more of a tube than is the case with the type form. Only three or four occur, and in one or two of them the tubular extensions are rather wider than in the one figured. The tests are compressed.—*Locality:* Two occur at No. **9.**

Pl. 20, fig. 6. This is very similar to the one figured by Mr. Millett, in his Malay Report, 1901, Pl. 14, fig. 15. Rather rare. —*Locality:* These specimens are mixed with those of other species and so the exact locality is uncertain.

Pl. 20, figs. 7, 8. These are similar to the *Challenger* figure, pl. 60, fig. 29. The examples vary both in size and in the amount of compression of the basal extensions. The internal tube is straight. About thirty-eight occur.—*Locality:* Nos. **3**, **13**, **26**, and many others.

Pl. 20, figs. 9, 10 (round in section). As some of the well-known Lagenae, which are typically round in section, have also their compressed form, so one would expect that some of those which are typically compressed would be occasionally represented by specimens which are round in section. Such is the case with these. The tube is free and much twisted.—*Locality:* It occurs at thirteen stations, but chiefly at Nos. **1**, **23**. Always rare.

Pl. 20, fig. 11. There are only two or three of this minute form. The tube is attached and the test well compressed.—*Locality:* Exact locality uncertain.

Pl. 20, fig. 12. In these the tubular processes at the base are comparatively long. The entosolenian tube is long, more or less attached, and curled back after nearing the base of the test. Aperture compressed. About thirty are on the slide.—*Locality:* Chiefly at No. **1.** Rare at Nos. **3, 9, 14, 25.**

At No. **11** nine occur of the same outline, but the tubular processes only just project and the internal tube is much shorter.

Pl. 20, figs. 13, 14. Mr. Millett in his Malay Report, 1901, pl. 14, figs. 14, 16, only figures the contorted and trifacial form of this beautiful variety of *L. auriculata.* Fig. 13 represents the variety in its normal condition and there are forty-seven on the slide.—*Locality:* Chiefly Nos. **1, 11, 19, 21.** Fig. 14 is the contorted form. None of the examples show the "auricular" portion carried so far up towards the neck as is represented in Mr. Millett's figure.—*Locality:* Chiefly Nos. **1, 11, 19, 21.** Thirty occur.

Lagena auriculata Brady var. (Pl. 20, figs. 15–18).

Pl. 20, fig. 15. The test is generally slightly roughened and the tube is attached. The body of the test is circular, or ovate, and compressed. The drawing is taken from the largest of the specimens. Several of the smallest have the orifice opening forwards.—*Locality:* Chiefly at No. **32,** and rarely at several other stations.

Pl. 20, fig. 16. A solitary specimen, in which the outline of the carina is nearly square.—*Locality:* Station uncertain.

Pl. 20, fig. 17. There are several examples in which the carina stops short of the tubular processes, or only just reaches them.

Pl. 20, fig. 18. In these the carina is confined to the base of the test and the entosolenian tube is of extraordinary length.—*Locality:* Chiefly No. **19.** Very rare.

Lagena auriculata Brady var. nov. *arcuata* (Pl. 20, figs. 19, 20.

The costae at the lower end of the test form a series of tall arches. In one or two instances the base between the tubular projections is armed with a long spine. The examples are small, and are marked as occurring at eight stations, but being mixed with those of another species the stations are uncertain. It occurs at any rate at No. **9**. The internal tube is attached.

Pl. 20, fig. 20. There are one or two specimens in which the costae do not become arched, and I take them to be feeble examples of the above. It is possible that they may be a weak form of *L. auriculata* var. *costata* Brady, 1884, pl. 60, fig. 38.

Lagena auriculata Brady var. *costata* Brady (Pl. 20, figs. 21, 22).

Lagena auriculata Brady var. *costata* Brady, 1884, pl. 60, fig. 38.

Except that the costae are more numerous and the tubular processes narrower, the specimens agree fairly well with Brady's description of the species.—*Locality:* Uncertain.

Lagena auriculata Brady var. nov. *duplicata* (Pl. 20, fig. 23).

In this case, instead of there being only two tubular processes at the base of the test, there are four, two on either side of the carina. It might be looked upon as a variety of *L. alveolata* var. *substriata* Brady, but the basal extensions are more characteristic of *L. auriculata*. Three found.—*Locality:* Nos. **10, 17**.

Lagena fimbriata Brady (Pl. 20, figs. 24–26).

Lagena fimbriata Brady, *Quart. Journ. Micr. Sci.*, vol. 21, N.S., 1881, p. 61.
Lagena fimbriata Brady, 1884, p. 486, pl. 60, figs. 26–28.

There is a single fractured specimen similar to the *Challenger* illustration, pl. 60, fig. 28.—*Locality:* Uncertain.

Pl. 20, figs. 24, 25. These come pretty near to the *Challenger* example, pl. 60, fig. 27. Most of the specimens are not quite so broad as the one figured. Owing to debris, or shell-growth, clogging the enclosed space at the base, I cannot be quite certain if the walls are traversed by tubuli; at any rate, they are often crinkled. There is no entosolenian tube. Nineteen occur.—*Locality:* Fig. 24, chiefly at Nos. **3**, **9**. Fig. 25, only three found, No. **28**.

Pl. 20, fig. 26. In the *Challenger* Report Brady gives no detailed description of his fig. 26, pl. 60, but his drawing shows a series of spines at the base, although one cannot be certain if they are intended to be on the edge of the oval wing surrounding the base. I should have taken them to be on the edge but that all the specimens in these gatherings show the spines running in a line from one side to the other through the centre of the enclosed space. It is obvious, I think, that the specimens are the same as the one figured by Brady. Upon examination the base of the test turns out to be very complex. There are two large specimens in this set of gatherings, one of which is in fine condition; and after comparing these with others from a different set of soundings, it is possible to come to a fairly accurate conclusion as to the nature of the complex base. As stated before, the spinous ridge runs from side to side through the centre. There appears to be a small, oval ridge placed centrally, as shown in the drawing, fig. 26*b*, and from this a series of closely set plates, standing on edge, radiates all round as far as the outer oval wing. The spaces between the plates are nearly always filled with granular shell-growth. A few small doubtful examples also occur.—*Locality:* Nos. **9, 17.**

Lagena fimbriata Brady var. nov. *occlusa* (Pl. 20, figs. 27, 28).

There are numerous examples of this elongate variety, some of which are much more compressed than the one figured, while others are broader as compared with their length. The entosolenian tube is long and has a coil in it near the orifice. The opening at the base is often nearly closed. The aboral wing is semi-opaque and wrinkled, but the opaqueness may be due to the granular shell-growth, or debris, with which the enclosed space is blocked. I cannot be certain if this basal compressed wing is traversed by tubuli. The orifice appears to be small and circular.—*Locality:* Occurs at many stations, chiefly Nos. **1, 6, 13, 18, 28, 32.**

Pl. 20, fig. 28. Of this short form, which I think may be taken as a variation of the above, there are only three or four examples.—*Locality:* Uncertain.

Lagena fimbriata Brady (?) (Pl. 21, fig. 17).

The body of the test is nearly circular in outline and compressed. The long neck is supported on either side by a wing.

At the base there is an oval flange, which projects more especially at the sides. This is a provisional description of the form, as the specimen may be in an imperfect condition. It is the best example on the slide.—*Locality :* Six are marked as being found at No. **11.**

Lagena alveolata Brady (Pl. 21, figs. 1, 2).

Lagena alveolata Brady, 1884, p. 487, pl. 60, figs. 30, 32.

Pl. 21, fig. 1. The tests vary a good deal in outline, but the majority are pyriform. The two lateral carinae, which unite with the median to form the loops at the base, are rough, or striated, and frequently drawn together so that the openings are nearly closed. The tube is straight.—*Locality :* Chiefly No. **32.** It occurs rarely at a good many stations.

Pl. 21, fig. 2. There are three fine specimens which are only very slightly compressed, and the division between the loops on each face of the test is very small.

Pl. 21, fig. 2*b* shows the base, its divisions being filled with granular matter. I think it probable that the walls at the base are partially broken down.—*Locality :* Uncertain.

Lagena alveolata Brady var. nov. *carinata* (Pl. 21, fig. 3).

This differs from the type in that the test is carinate. One example is in the trifacial condition.—*Locality :* Chiefly Nos. **6, 7, 18.**

Lagena alveolata Brady var. *substriata* Brady.

Lagena auriculata var. *substriata* Brady, 1881, *Quart. Journ. Micr. Sci.*, vol. 21, N.S., p. 61.

Lagena alveolata var. *substriata* Brady, 1884, p. 488, pl. 60, fig. 34.

Two only occur.— *Locality :* Nos. **30, 34.**

Lagena alveolata Brady var. *caudigera* Brady (Pl. 21, fig. 4).

Lagena alveolata var. *caudigera* Brady, 1884, p. 488, pl. 60, fig. 25.

Although the specimen shows signs of wear in the region of the loops, I think there is no doubt that it is rightly placed under this heading. One only found.—*Locality :* No. **29.**

Lagena alveolata Brady var. nov. *separans* (Pl. 21, fig. 5).

Test compressed, almost circular in outline, ovate, or pyriform. Four independent, narrow loops at the base, two on either side. Entosolenian tube short and coiled. Orifice rather compressed.

I think this interesting form should be treated as a variant of *L. alveolata*, rather than as one of *L. auriculata*, the two loops on either side of the base being separated. The type form is "furnished with a median and two lateral carinae, which unite to form two loops on either side of the test." There are over forty on the slide.—*Locality:* Chiefly Nos. **3, 13, 17, 18, 28, 30, 32.**

Lagena clypeato-marginata Rymer Jones var. (Pl. 21, fig. 6).

Lagena vulgaris Williamson var. *clypeato-marginata* Rymer Jones, 1872, p. 58, pl. 19, fig. 37.

Although not quite typical, I think the specimens may come under this heading. There are no spines and the base of the chief keel is not always serrated. Some of the specimens have the space between the orifice and the body of the test shorter, and the keel at the base more rounded off, than in the one figured. Eight found.—*Locality:* Nos. **8, 14,** and several other stations.

Lagena clypeato-marginata Rymer Jones var. nov. *crassa* (Pl. 21, fig. 7).

Of this very robust variety there are only two specimens, and they are in good condition. The neck is decorated with four stout costae, two on either side. The lower part of the body of the test is pitted, in most cases irregularly, but sometimes the markings are arranged in lines. The lower edge of the pitted portion projects as a flange.—*Locality:* Nos. **3, 14.**

Lagena magnifica sp. nov. (Pl. 21, fig. 8).

Test compressed, occasionally round in section. The neck is long and the orifice phialine. The base is apiculate and there are two spines, one on either side of the apiculate process. The body of the test is covered at regular intervals with short, blunt, tubular spines, each of which has its orifice minutely phialine. Running round the edge of the test are three or four rows of the spines, which are sometimes connected so as to form a ridge. The orifices of the spines show quite distinctly under a magnification of seventy-five diameters. The test when fresh is semitransparent, but most of the specimens are opaque and roughened by granular shell-growth, which fills up the spaces between the tubular spines. There are twenty on the slide, one or two of which are round in section, or nearly so. This form may be related to *L. hispida*, which, though typically round in section, occurs also in the compressed condition, but the nature of the spines is distinctly different.—*Locality:* Eleven found at No. **1**, two at No. **18**, three at No. **30**, and odd ones at a few other stations.

Lagena elcockiana Millett (Pl. 21, fig. 9).

Lagena elcockiana Millett, 1901, p. 621, pl. 14, figs. 5, 6.

There were twelve specimens on the slide, but there are only two now, owing to an unfortunate accident. They were all similar to the one figured. Mr. Millett states that it is rare in the Malay Archipelago and only found at a few stations in Area 2.—*Locality:* One found at No. **18**, ten at No. **19**, and one at No. **20**.

Lagena soleaformis sp. nov. (Pl. 21, fig. 10).

This is a difficult Lagena to describe. Taking as the front of the test that side which shows the orifice of the attached, entosolenian tube, we are reminded of a horse-shoe. The carina is slightly convex on the front and concave at the back. The central portion (the body of the test) is flattened, and slopes backwards at the base, but the back is highly convex and produced at the base as a curved flange. Eight found.—*Locality:* Six at No. **19**, one at No. **20**, and one at No. **21**.

Lagena galeaformis sp. nov. (Pl. 21, figs. 11, 12).

Test nearly square in section. It is carinate at the angles, and broader at the base than at the orifice, which is square. A tubular process projects at each corner of the base. The body of the test is covered with fine, broken-up striae.

I believe the type form to be four-sided, as it occurs very rarely in the trifacial condition (see fig. 12).—*Locality:* Chiefly Nos. **1**, **13**, **17**, **19**.

Note.—There are a few of the three-sided ones in which the tubular processes are absent, but they appear to belong to the same set.

Lagena semicostata sp. nov. (Pl. 21, fig. 13).

Test compressed, irregularly ovate, the upper part squared off at the sides. The entosolenian tube is straight. A series of very fine, curving costae, running parallel to each other, partially encircles the sides and lower half of the test. At the base, on either side, is a ridge that divides the curving costae into two sets. Only one found.—*Locality:* No. **34**.

Lagena sacculiformis sp. nov. (Pl. 21, fig. 14).

Test oblong, apiculate, asymmetrical, one side being very convex, the other only slightly so, and always having a compressed part at the centre of the slightly convex side. Orifice at the end of a short neck, which is placed at the junction of the two sides. There is no internal tube, and the surface of the shell is smooth and polished.—*Locality:* One found at No. **2**, one at No. **11**, and five at No. **19**.

Lagena protea Chaster.

Lagena protea Chaster, 1892, p. 62, pl. 1, fig. 14.

Nineteen are marked on the Chart, and they vary in size and shape. There can be little doubt that this form is generally adherent. After studying the large numbers that have come under my observation from many localities, I am of opinion that Dr. Chaster was right in treating them as true Lagenae.

In a letter dated from Southport, February 8th, 1897, he wrote me as follows, and I know that up to the time of his death he had not changed his opinion:

"I note your remarks upon my *Lagena protea.* That Messrs.

Jones and Chapman are utterly in error in referring my specimens to Ramulina is a matter quite beyond doubt. As genera and species in the Foraminifera go, they have nothing whatever in common beyond a superficial resemblance. *L. protea* always has but a single chamber and a single aperture. Now, Ramulina fragments have always several open tubular projections, or when much broken the corresponding apertures are left. It might be urged that *L. protea* is the initial chamber of Ramulina. This is disproved by the absence of Ramulina in dredgings where *L. protea* is abundant, and still more conclusively by the fact that the initial chamber of Ramulina is known. Schlumberger has found perfect specimens of *R. grimaldii* Schlumberger. These commence, as one would expect, as a Polymorphina, and afterwards take on the ramuline growth. Ramulina may, indeed, be considered as one of the fistulose Polymorphinae, and is to my mind one of the genera that might well be dropped. I have found *L. protea* in profusion, have examined specimens with great care, and can positively pronounce them to be true Lagenae, and not the young or imperfect examples of anything else. Any one who will examine my series, yours, or take the trouble to hunt out a sufficient number of examples for himself, will come to the same conclusion. The specimens vary considerably, and it would not be difficult to make a series of all intermediate gradations between *L. protea* and *L. laevis.* This, however, is the case with many or most 'species.' I am sorry to have to differ from other authorities, but when, after the exercise of every caution, I find I am right, there is no other course, especially as the others do not appear to have anything beyond a vague surmise on which to base their opinion."

There is no doubt great difficulty in distinguishing abnormal examples of *L. hispida* Reuss from some of the forms of *L. protea.* —*Locality:* Chiefly Nos. **1, 19, 29**.

DESCRIPTION OF PLATES.

PLATE 14.

Figs.		Page
1–3.	*L. globosa* Montagu sp., × 75	379
4.	*L. globosa* Montagu sp., × 50	—
5.	*L. globosa* (compressed form of fig. 4), × 50	—
6.	*L. globosa* (compressed form of fig. 4), × 75	—
7–9.	*L. globosa* (figs. 7, 8, bilocular forms), × 75	380
10, 11.	*L. globosa* Montagu sp. var. nov. *maculata*, × 75	—
12.	*L. globosa* Montagu sp. var. nov. *annulata*, × 75	—
13–15.	*L. globosa* Montagu sp. var. *emaciata* Reuss, × 75	381
16.	*L. apiculata* Reuss, × 50	—
17.	*L. apiculata* Reuss, × 25	—
18–20.	*L. apiculata* Reuss, × 50	—
21–23.	*L. apiculata* Reuss var. nov. *punctulata*, × 50	382
24, 25.	*L. botelliformis* Brady, × 50	383
26, 27.	*L. botelliformis* Brady, × 75	—
28.	*L. botelliformis* Brady, × 50	—
29.	*L. botelliformis* Brady, × 50	—
30.	*L. botelliformis* Brady (?) var. nov. *rugosa*, × 75	—
31.	*L. hispida* Reuss, × 50	385

PLATE 15.

Figs.		Page
1.	*L. hispida* Reuss, × 75	385
2.	*L. hispida* (compressed variety), × 75	—
3–5.	*L. hispida* Reuss var. nov. *tubulata*, × 50	—
6, 7.	*L. striata* d'Orbigny sp., × 75	386
8.	*L. striata* d'Orbigny sp., × 50	—
9, 10.	*L. striata* d'Orbigny sp., × 75	—
11, 12.	*L. striata* d'Orbigny sp. var. nov. *striatotubulata*, × 75	387
13.	*L. variata* Brady, × 115	—
14, 15.	*L. lineata* Williamson sp., × 75	—
16–20.	*L. costata* Williamson sp., × 75	388
21.	*L. costata* Williamson sp. (?), × 50	—
22.	*L. acuticosta* Reuss, × 75	—
23.	*L. acuticosta* Reuss, × 50	—
24, 25.	*L. sulcata* Walker and Jacob sp., × 50	389
26.	*L. thornhilli* sp. nov., × 75	390
27.	*L. striato-areolata* Rymer Jones, × 50	—
28, 29.	*L. stelligera* Brady, × 75	391

PLATE 16.

Figs.		Page
1, 2.	*L. stelligera* Brady, × 75	391
3.	*L. stelligera* Brady, × 50	—
4.	*L. stelligera* Brady, × 75	—
5, 6.	*L. stelligera* Brady var. nov. *eccentrica*, × 75	392
7–9.	*L. striatopunctata* Parker and Jones, × 75	—
10.	*L. striatopunctata* P. and J. (?), × 75	—
11.	*L. striatopunctata* P. and J. (?) var. nov. *complexa*, × 50	393
12.	*L. striatopunctata* P. and J. var. nov. *inaequalis*, × 75	—
13.	*L. striatopunctata* P. and J. var. nov. *fusiformis*, × 50	394
14.	*L. striatopunctata* P. and J. var. *spiralis* Brady, × 115	—
15.	*L. foveolata* Reuss, × 115	395
16, 17.	*L. foveolata* Reuss var., × 75	—
18–21.	*L. foveolata* Reuss var. nov. *spinipes*, × 75	—
22, 23.	*L. foveolata* Reuss (?) var. nov. *paradoxa*, × 75	—
24.	*L. lamellata* sp. nov., × 50	396
25.	*L. lamellata* (shows the relative widths of shell-wall and test), × 50	—
26–28.	*L. hertwigiana* Brady var. nov. *undulata*, × 75	397
29.	*L. pacifica* sp. nov., × 75	398
30.	*L. spumosa* Millett, var., × 75	—
31.	*L. chasteri* Millett, × 75	—
32.	*L. chasteri* Millett, var. incert., × 75	—
33.	*L. chasteri* Millett var. incert., × 50	—
34.	*L. chasteri* Millett var. incert., × 75	—

Plate 17.

Figs.		Page
1–3.	*L. intermedia* sp. nov., × 75	399
4, 5.	*L.* sp. incert., × 50	—
6.	*L.* sp. incert., × 75	400
7.	*L. laevigata* Reuss sp. var., × 75	—
8.	*L. laevigata* Reuss sp. var. nov. *virgulata*, × 50	—
9.	*L. acuta* Reuss sp., × 50	401
10.	*L. acuta* Reuss sp. var. nov. *virgulata*, × 75	—
11.	*L. acuta* Reuss sp. var., × 75	—
12.	*L. lucida* Williamson sp., × 75	—
13.	*L. lucida* Williamson (round in section), × 50	—
14.	*L. lucida* Williamson (spinous condition), × 50	—
15.	*L. fasciata* Egger sp., × 115	402
16, 17.	*L. fasciata* Egger sp. var. nov. *spinosa*, × 50	—
18.	*L. fasciata* Egger sp. var. *carinata* Sidebottom, × 50	403
19.	*L. staphyllearia* Schwager sp., × 75	—
20.	*L. staphyllearia* Schwager sp., × 50	—
21–23.	*L. staphyllearia* Schwager sp., × 75	—
24.	*L. staphyllearia* Schwager sp., × 115	—
25.	*L. unguiculata* Brady, × 50	404
26–28.	*L. quadrata* Williamson sp., × 75	405
29.	*L. marginata* Walker and Boys, × 50	—
30.	*L. marginata* W. and B., × 75	—
31.	*L. marginata* W. and B., × 50	—

Plate 18.

Figs.		Page
1.	*L. marginata* Walker and Boys, × 50	405
2.	*L. marginata* W. and B., × 25	—
3.	*L. marginata* W. and B., × 50	—
4, 5.	*L. marginata* W. and B., × 50	407
6.	*L. marginata* W. and B., var. *catenulosa* Chapman, × 25	—
7.	*L. marginata* W. and B., var. nov. *umbonata*, × 75	—
8, 9.	*L. marginata* W. and B., var. nov. *raricostata*, × 75	408
10.	*L. marginata* W. and B., var. nov. *striolata*, × 50	—
11.	*L. marginata* W. and B., var. nov. *striolata* (?), × 75	—
12.	*L. marginata* W. and B., var. nov. *elegans*, × 75	409
13.	*L. marginata* W. and B., var. nov. *retrocostata*, × 115	—
14.	*L. marginata* W. and B., var. nov. *armata*, × 115	—
15.	*L. marginata* W. and B., var. nov. *homunculus*, × 75	—
16, 17.	*L. marginata* W. and B., var. *seminiformis* Schwager, × 75	410
18.	*L. marginata* W. and B., var. *seminiformis* Schwager, × 50	—
19, 20.	*L. marginata* W. and B., var. *seminiformis* Schwager, × 75	—
21.	*L. marginata* W. and B., var. *seminiformis* Schwager, × 50	—
22, 23.	*L. lagenoides* Williamson sp., × 50	411
24, 25.	*L. lagenoides* Williamson sp., × 75	—
26.	*L. lagenoides* Williamson sp., × 115	—
27.	*L. lagenoides* Williamson sp., × 75	—
28.	*L. lagenoides* Williamson sp., × 115	—
29.	*L. lagenoides* Williamson sp., × 50	—

PLATE 19.

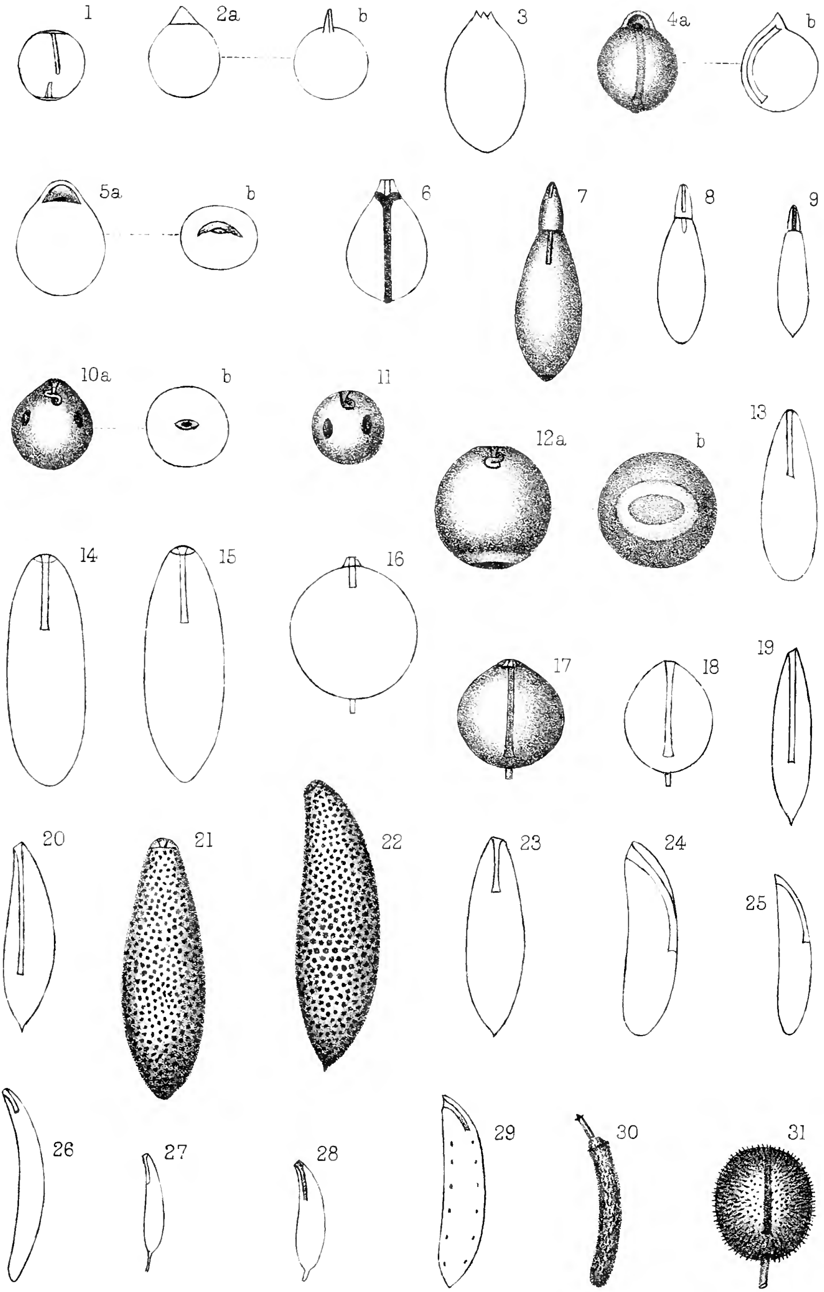
Figs.		Page
1–3.	*L. lagenoides* Williamson sp., × 75	411
4.	*L. lagenoides* Williamson sp. var. *tenuistriata* Brady, × 50	413
5.	*L. lagenoides* Williamson (Trigonal form), 50	—
6, 7.	*L. formosa* Schwager, × 50	414
8, 9.	*L. formosa* Schwager, × 75	—
10.	*L. formosa* Schwager var. *comata* Brady, × 75	415
11.	*L. formosa* Schwager var. *comata* Brady, × 115	—
12.	*L. formosa* Schwager var. *comata* (Trigonal form), × 115	—
13.	*L. orbignyana* Seguenza, var., × 75	416
14.	*L. orbignyana* Seguenza, var., × 75	—
15.	*L. orbignyana* Seguenza var. nov. *coronata*, × 50	—
16–18.	*L. orbignyana* Seguenza var. *lacunata* Burrows and Holland, × 50	—
19.	*L. orbignyana* Seguenza var. nov. *stellata*, × 75	417
20.	*L. orbignyana* Seguenza var. nov. *curvicostata*, × 50	—
21.	*L. orbignyana* Seguenza var. *walleriana* Wright, × 75	—
22.	*L. orbignyana* Seguenza var. nov. *unicostata*, × 75	—
23.	*L. orbignyana* Seguenza var. nov. *concentrica*, × 115	—
24.	*L. orbignyana* Seguenza var. *pulchella* Brady, × 75	418
25–27.	*L. bicarinata* Terquem sp., × 75	419

PLATE 20.

Figs.		Page
1.	*L. bicarinata* Terquem sp., × 75	419
2.	*L. bicarinata* Terquem sp. var. nov. *imbricata*, × 75	—
3.	*L. bicarinata* Terquem sp. var. nov. *horrida*, × 50	—
4–6.	*L. auriculata* Brady, × 75	420
7, 8.	*L. auriculata* Brady, × 50	—
9–14.	*L. auriculata* Brady, × 75	—
15–18.	*L auriculata* Brady, var., × 75	421
19.	*L. auriculata* Brady var. nov. *arcuata*, × 115	—
20.	*L. auriculata* Brady var. *arcuata* (?), × 75	—
21, 22.	*L. auriculata* Brady var. *costata* Brady, × 75	422
23.	*L. auriculata* Brady var. nov. *duplicata*, × 50	—
24.	*L. fimbriata* Brady, × 75	—
25.	*L. fimbriata* Brady, × 50	—
26.	*L. fimbriata* Brady, × 25	—
27, 28.	*L. fimbriata* Brady var. nov. *occlusa*, × 75	423

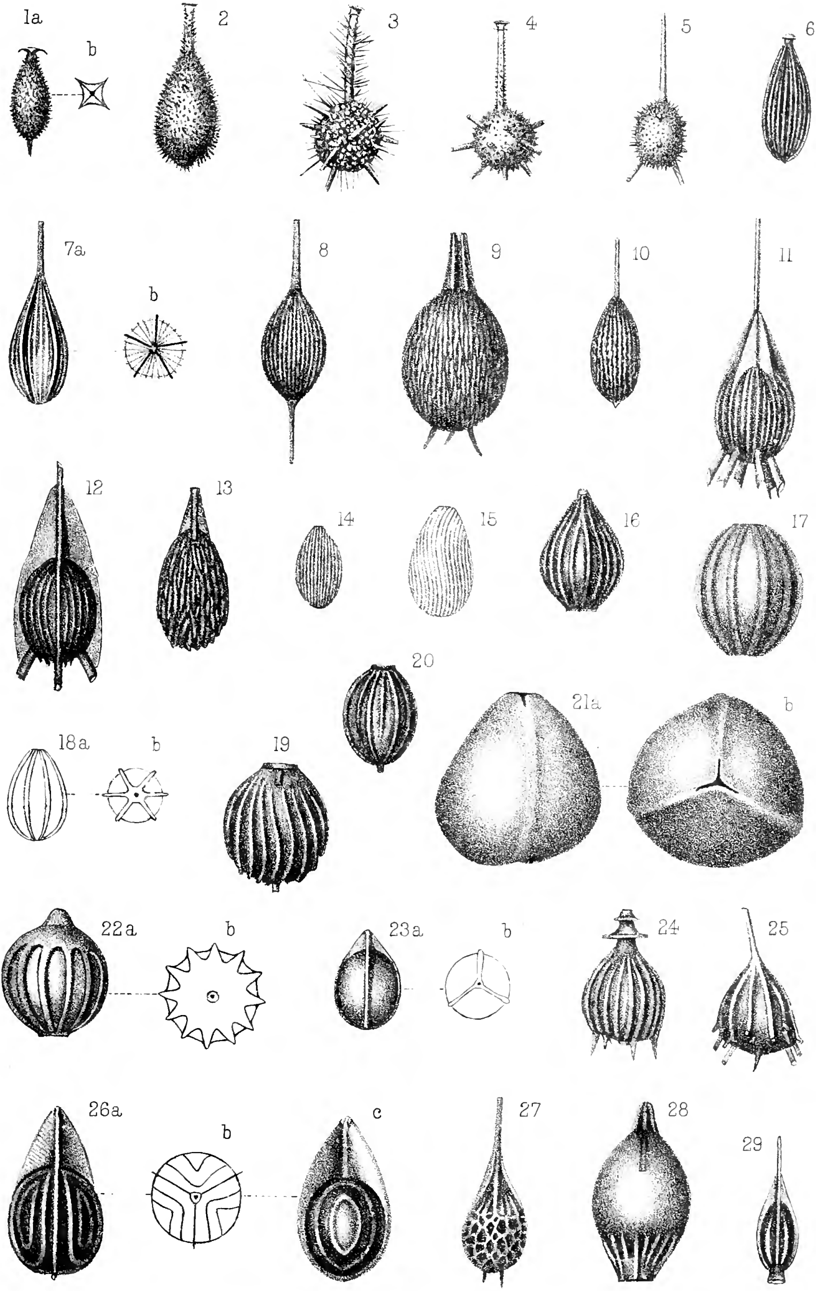
PLATE 21.

Figs.		Page
1.	*L. alveolata* Brady, × 75	424
2.	*L. alveolata* Brady, × 50	—
3.	*L. alveolata* Brady var. nov. *carinata*, × 50	—
4.	*L. alveolata* Brady var. *caudigera* Brady, × 25	—
5.	*L. alveolata* Brady var. nov. *separans*, × 75	425
6.	*L. clypeato-marginata* Rymer Jones var., × 50	—
7.	*L. clypeato-marginata* Rymer Jones var. nov. *crassa*, × 50	—
8.	*L. magnifica* sp. nov., × 50	—
9.	*L. elcockiana* Millett, × 115	426
10.	*L. soleaformis* sp. nov., × 115	—
11, 12.	*L. galeaformis* sp. nov., × 115	—
13.	*L. semicostata* sp. nov., × 50	427
14.	*L. sacculiformis* sp. nov., × 75	—
15.	*L. orbignyana* Seguenza (?), × 75	418
16.	*L. staphyllearia* Schwager var. nov. *quadricarinata*, × 75	404
17.	*L. fimbriata* Brady (?), × 75	423



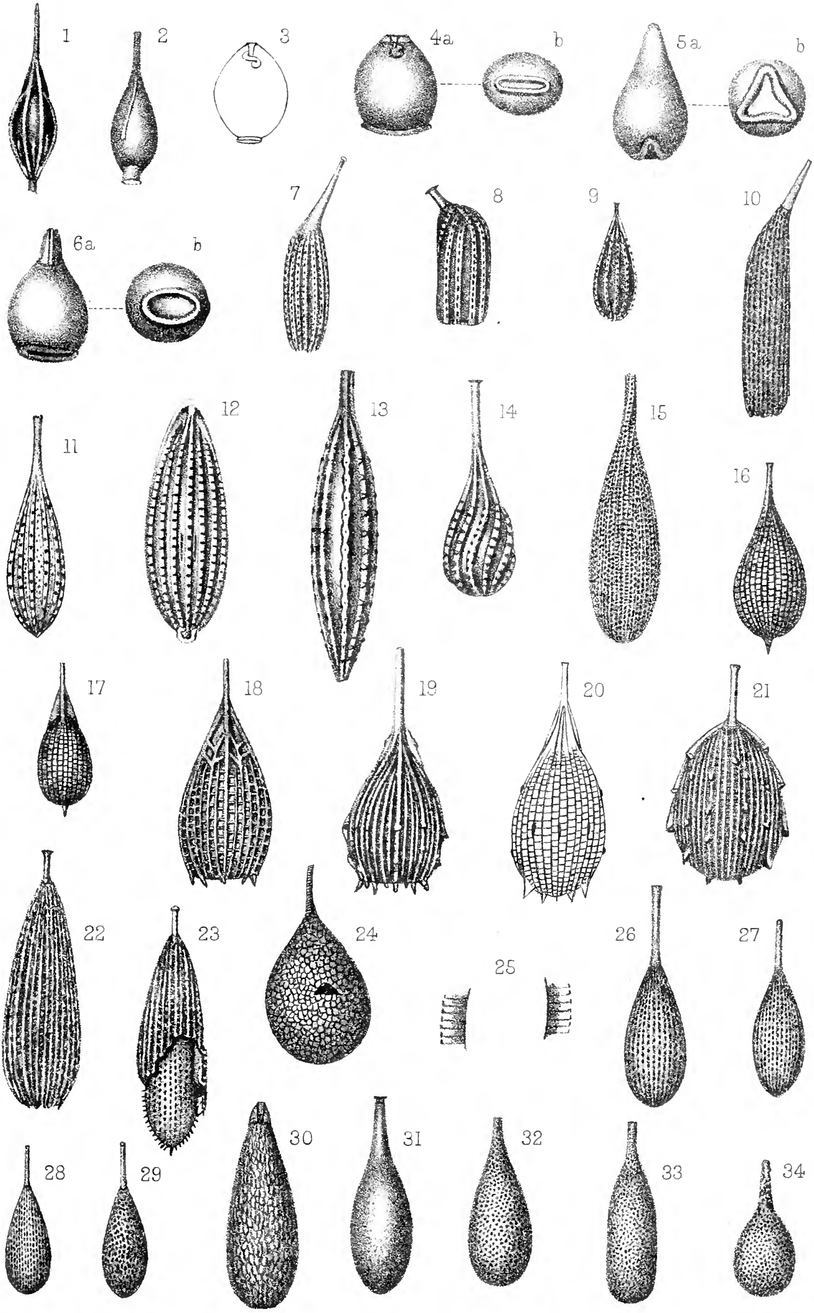
H. Sidebottom del ad nat.
West, Newman lith.

Lagenae of the South West Pacific Ocean.



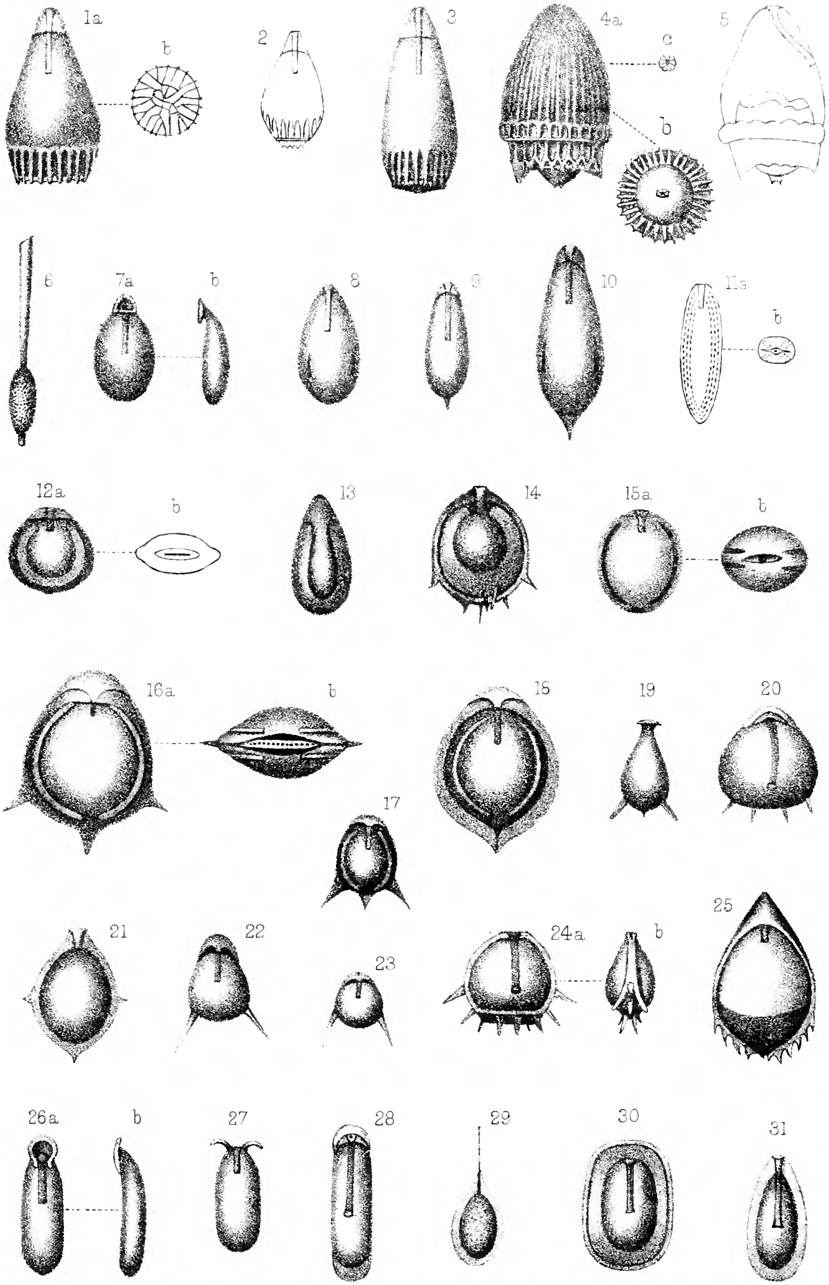
H. Sidebottom del. ad nat. West, Newman lith.

Lagenae of the South West Pacific Ocean.



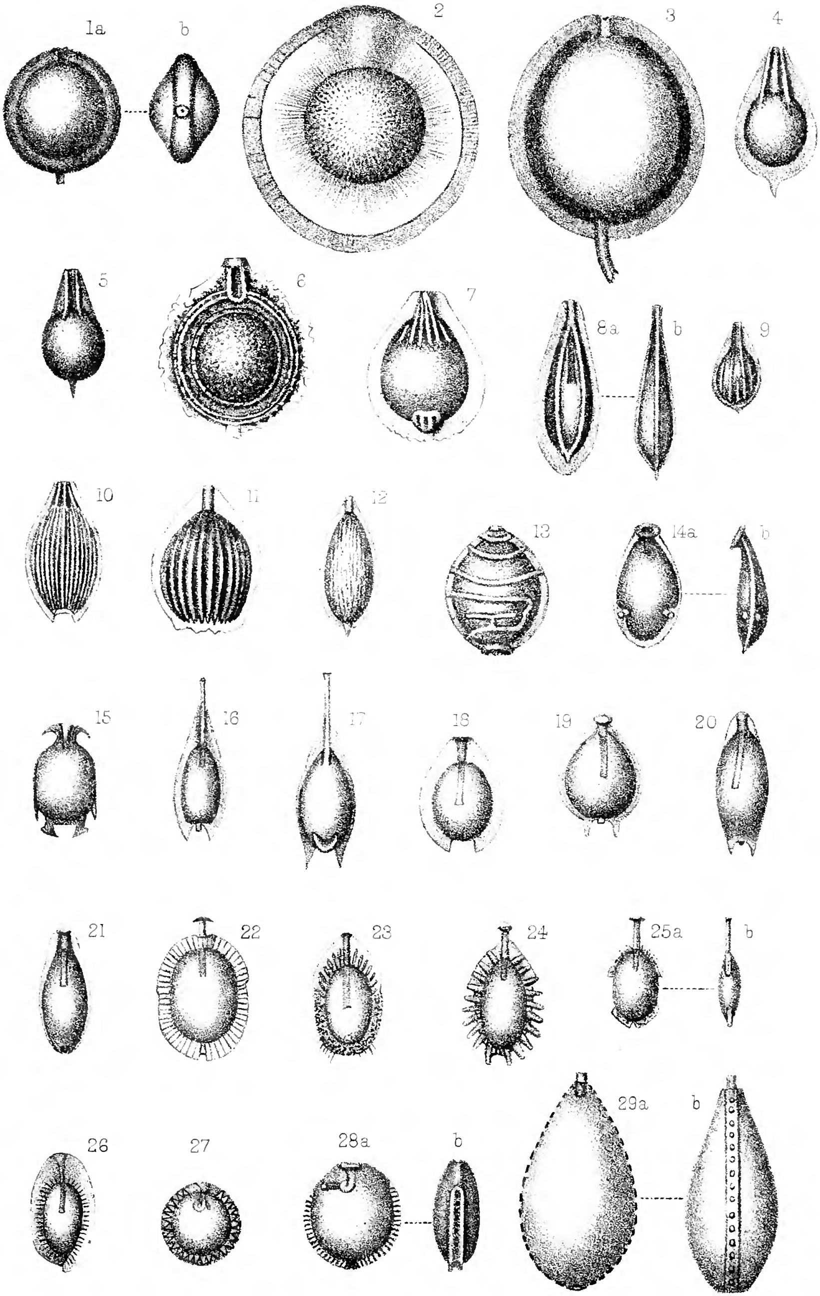
H. Sidebottom del. ad nat.
West, Newman lith.

Lagenae of the South West Pacific Ocean.



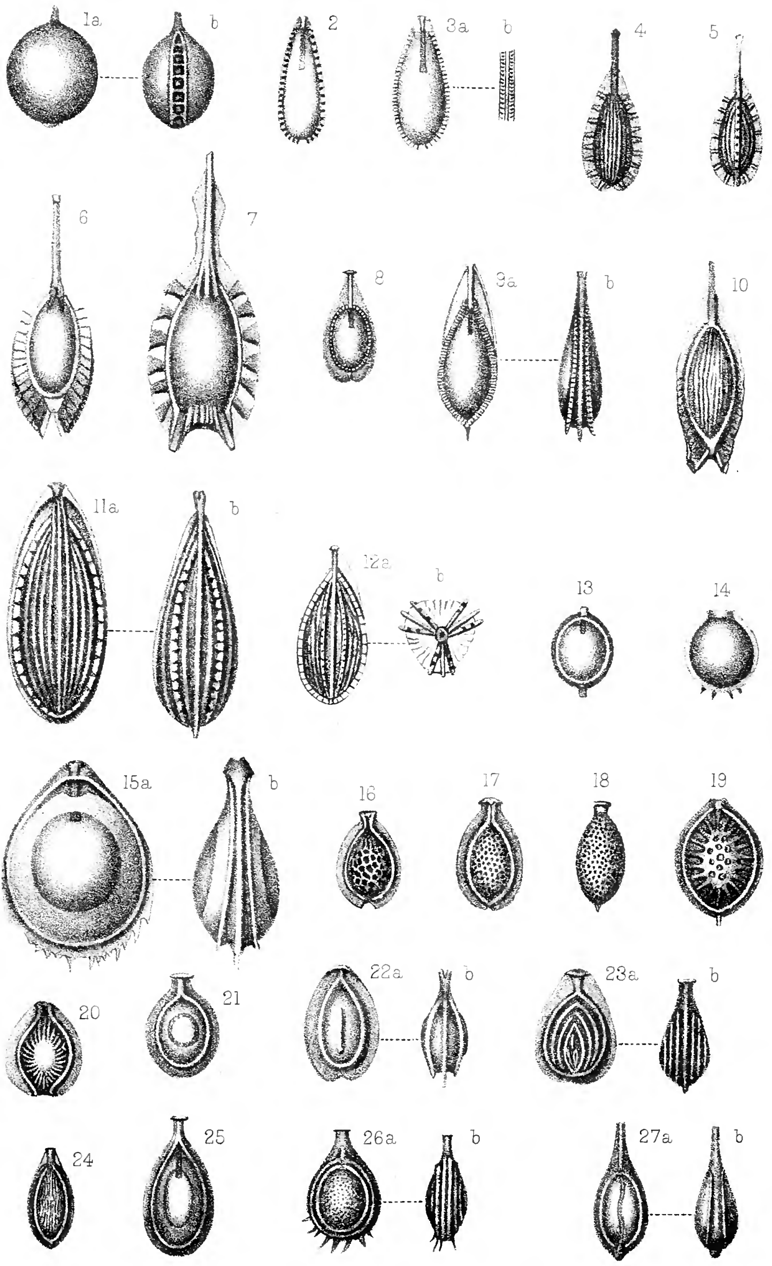
H. Sidebottom del. ad nat. West, Newman lith.

Lagenae of the South West Pacific Ocean.



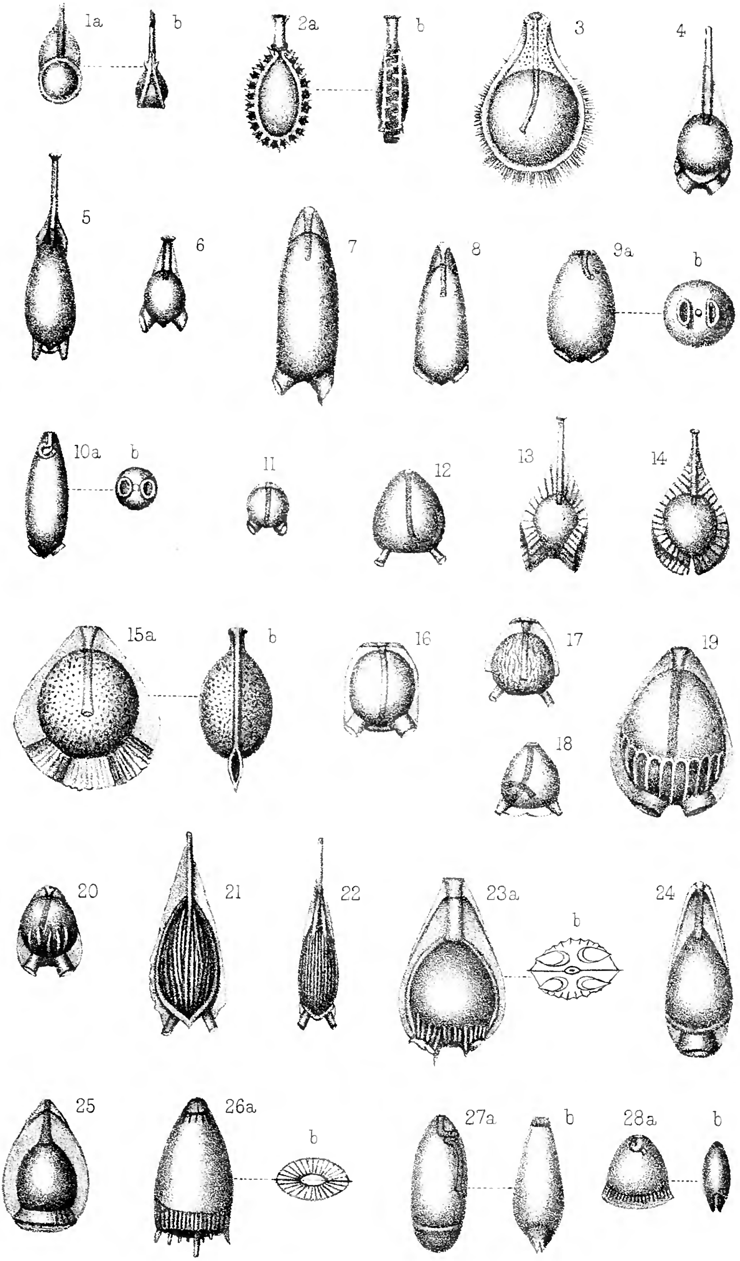
H. Sidebottom del. ad nat.
West, Newman lith.

Lagenae of the South West Pacific Ocean.



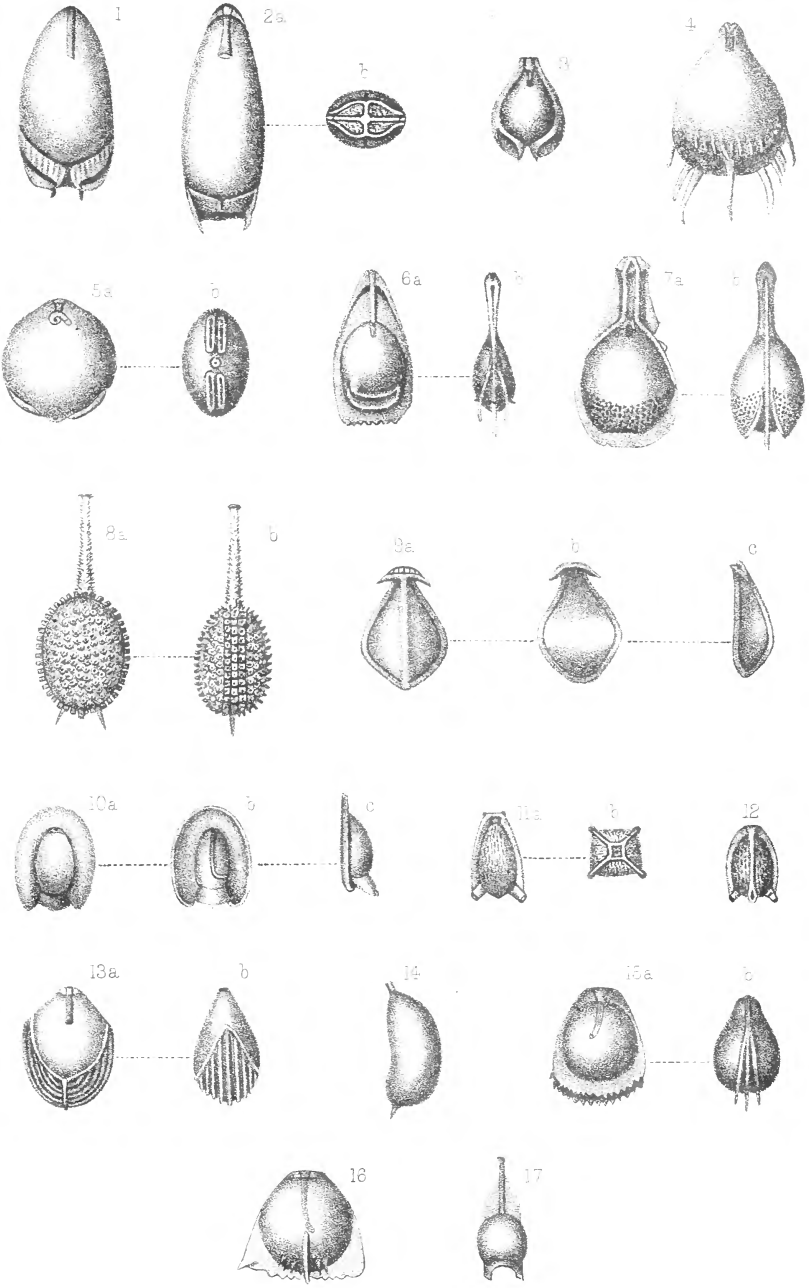
H. Sidebottom del. ad nat. West, Newman lith.

Lagenae of the South West Pacific Ocean.



H. Sidebottom del. ad nat. West, Newman lith.

Lagenae of the South West Pacific Ocean.



H. Sidebottom del. ad nat. West, Newman lith.

Lagenae of the South West Pacific Ocean.

NOTES ON ALGAE COLLECTED IN 1911.

By James Burton.

(*Read January 23rd*, 1912.)

I suppose if it were possible to achieve the ideal in speaking of any of the various classes of natural objects which interest us, one would bring forward a more or less lengthy list of new species, all accurately described, named and labelled. No doubt new species are dear to all of us, but very little consideration and quite a small amount of experience convince most that such a delightful consummation is not likely to fall to the lot of many, and that, rather, we may be duly thankful and contented to have come across during the season, a few examples new to us only by reason of our not having found them previously, and that we can find ready named and described in some of the books written by masters in whatever department may happen to be of interest to us. Such is all the result I dare to hope for and all I can offer you in this short paper.

I wish to speak of some of the Algae collected by myself in 1911, especially those exhibiting the phenomena known as the "breaking of the meres." This expression or its equivalent is quite well known in some districts and in places abroad, and is ordinarily used—in Shropshire, for example—to express that condition of the lakes and other bodies of water, when they are so permeated with one or more species of Algae as to lose their transparency and to assume the colour of the organism which is so plentiful in them. Angling, for the time during which the condition exists, has usually to be given up, as the fish refuse to bite, and in extreme cases the water is injurious or even poisonous to animals drinking it. The first instance I noticed in 1911 was on our excursion to Totteridge, on June 24th. In one of the ponds there the water was a deep transparent green, but was not thick or opaque; a bottleful had about the same appearance, but nothing could be detected with an ordinary low-power hand-lens. Examination under the microscope showed the colour to be due partly to the presence of various small organisms—motile gonidia and others of an indefinite character, with a few *Euglena viridis*, but chiefly to the presence in large numbers of a species of Anabaena which was new to me. A closely related genus (Nostoc) is well known to most microscopists; they consist usually of very much twisted and convoluted strings of small bead-like cells embedded in a gelatinous matrix; there are both aquatic and terrestrial species, and are fairly common. The species of Anabaena resemble them very closely, the chief difference being that in these the jelly is quite or almost absent and the filaments instead of being convoluted are more often straight or slightly curved; they are found as aquatic organisms only. The specimen from Totteridge was formed of the usual bead-like cells, but the filaments were coiled into a fairly regular spiral, or rather helix. The cells were about 5 μ in diameter, filled with bluish-green protoplasm, with numbers of darker granules in it. Most of the coils had in them a cell known as a heterocyst—paler in colour and without granules. The function of these is uncertain, but the filaments often multiply by dividing where they occur. Sometimes the direction of the spiral changed at the heterocyst, and usually the turn containing one was smaller than the normal, giving rise often to a peculiar M-shaped figure. Spores were not infrequent; they are formed from the ordinary cells, but become oval, larger, and have denser contents. The coils were short, having from two to four or five turns. Later in the year what was obviously the same organism, but in a somewhat different condition, was met with at Barnet, on our excursion to Hadleigh Common, in September. In this case spores were not present, and heterocysts were rare, while the coils of the plant were very much longer than in the other case, often reaching ten to fifteen or more turns. A singular fact in both cases was that it seemed impossible to concentrate the organism by using the collecting-net; this was of no consequence, however, as it was so abundant that a dip with a tube secured plenty. I could not find a description of any species that corresponded to this in either of Dr. Cooke's books, or in West's *British Freshwater Algae.* The nearest seemed to be *A. circinalis,* and under that name a notice of it appeared it *Knowledge*; but the form is not circinate, when undamaged, but spiral. It is as though the filaments were wrapped round a cylinder. Hassall (published 1845), however, has a figure—very small and not very distinct—which appears to represent it; he calls it *Spirillum Thompsoni,* but gives as a synonym *Anabaena spiralis* (Thompson). The habitat is given as Ballydrain Lake, near Belfast, and there is a description by Thompson of its occurring in great quantity there. He says: "The specimens obtained were invariably of similar breadth, and rarely presented more than four spiral turns; and when of this size were $\frac{1}{50}$th of an inch in length." Further on he refers to its "exact spiral form," but there is no adequate description for identification. The measurement seems to me wrong (I made it out very much smaller: $\frac{1}{500}$ to $\frac{1}{1000}$ in.); the magnification is not given with the figure. Why it should be omitted from Dr. Cooke's book, if he had come across it, it is difficult to say; for the form is so very characteristic and so different from most Anabaenae, though agreeing perfectly in other respects, that one would have thought it could not be overlooked. Prof. West's book does not deal with more than the common species, but describes *genera* exhaustively.

Another example of the blue-green Algae which presents several interesting features is *Aphanizomenon flos-aquae.* I had not come across it till last year; but it is recorded as occurring annually in great abundance in the large piece of water known as the "pond" near the Palm-house in Kew Gardens. On August 28th the water was suffused with it at all depths. It consists of short filaments of cylindrical cells about 4 to 5 μ wide, the divisions slightly constricted; a heterocyst with clear contents is usually present. The filaments adhere to each other in numbers, forming flakes or scale-like objects of considerable size, easily visible to the naked eye. The protoplasm is bluish green with darker granules. A fortnight later the plant had increased in amount, till on the lee side it formed a thick pasty mass, which the waterfowl avoided. It produces spores, long and somewhat thicker than the filament, but there were very few on the first date, and later, when there were more, it was evident that the organism was breaking up, and from that time it gradually disappeared. It cannot usually be found in this water at any time. It has been stated that with it is generally found another organism, Clathrocystis, but I found none; on the occasion when the Aphanizomenon was first seen, there was present with it in almost equal amount the beautiful *Eudorina elegans.* This is most likely better known than the other; it is of considerable size, and from its elegant shape and graceful motion is not unlike the closely related *Volvox globator.* It belongs to the Chlorophyceae—the green Algae—and is a much higher organism than Aphanizomenon. I have not read or heard of its occurring in such abundance, and it had entirely disappeared on the second visit a fortnight later.

A well marked example of the "breaking of the meres" on a large scale happened in the summer of 1911 at the Brent Reservoir. On August 31st the whole of the water of one division of the lake was of a distinct pale green; near the edge on the lee side the appearance was most remarkable. The water resembled green oil or thin paint; it was being drawn off, and in consequence the bank for some distance from the edge, and the various debris and rubbish left on the bank, were covered with a thick deposit of the organism. I have a small stone which was picked up and brought away as an example, and a walking-stick which was stirred in the water looked exactly as though it had been painted. The plant in this case is an exceedingly small spherical body measuring about 3 μ in diameter. It is pale green, becoming blue-green on drying. These multiply by repeated division in all directions, and ultimately form families or colonies of the most various shapes and size. In this particular species they are mostly small and remain solid, though sometimes when older become indefinite in outline and torn. It belongs to the blue-green Algae, and is low down in the scale even for them. The colonies are often aggregated in large masses, the shape to a great extent depending on the prevailing conditions. It occurred in a similar way to that described in the Serpentine a few years ago, and the small waves set up by the wind rolled it into masses more or less globose, and into sausage-shaped bodies often measuring 2 to 4 in. in length. It is called *Microcystis marginata.* A member of the Club during last summer brought me a tube of it for identification, in which the colonies were of quite typical form as far as can be in such a case. The species is quite common in some of the ponds in Richmond Park. Perhaps the most interesting record is one that Dr. Cooke calls *Clathrocystis aeruginosa* (Kütz), but Prof. West puts it in the same genus as the example I have been speaking of, and calls it *Microcystis aeruginosa.* I came across it in the small lake in the Zoological Gardens at Clifton, Bristol, early in September last. It was plentiful in all parts of the water at all depths, but on the side to which it was blown by the wind it was as thick as porridge. It was impossible to dip it out with a bottle, it became a pasty and useless mass at once; one had to fill the tube at some part where it was less dense. As usual under the circumstances, the unlucky waterfowl were having a bad time, and looked green and draggled. The units forming the colonies scarcely differed from those already described, measuring 3 to 4 μ, but they show a tendency to form large open net-like bodies often of considerable size and of the most diverse shape up to 2 or even 3 mm. in length.

Dr. Cooke writes of this species: "Fronds gelatinous, at first solid, then saccate, ultimately clathrate, composed of a colourless matrix in which are embedded innumerable minute cells, which multiply by division within the frond. Fronds floating in vast strata on freshwater pools, forming a bright green scum, when dried appearing like a crust of verdigris. Cells minute, $2\frac{1}{2}$ to $3\frac{1}{2}$ μ."

NOTES ON EXHIBITS.

By E. M. Nelson, F.R.M.S.

(*Read January 23rd*, 1912.)

Plate 22, figs. 1 and 2.

The following photomicrographs were shown by the Hon. Secretary in the absence of Mr. E. M. Nelson :

Slide 1.—Eye-spot of *Coscinodiscus asteromphalus*, Maryland deposit, styrax mount, showing fracture passing through cap × 3,000 diams. (Pl. 22, fig. 1).

The negative from which this lantern slide was made, by contact printing, was taken direct, and neither it nor the lantern slide has been intensified, reprinted, enlarged or touched up in any way. (This remark applies to all the slides.) It is obvious that the presence of a fracture proves the existence of a membrane covering the eye-spot (Pl. 22, fig. 2).

Slide 2.—Tubercle Bacillus from sputum showing the so-called flagellum × 4,150 diams.

This preparation was made in the middle of last month (December 1911) by Dr. A. C. Coles, of Bournemouth, who has kindly sent me the following particulars concerning it: " From sputum stained in ordinary way with Ziehl Neelsen's method and decolourised in 25 per cent. sulphuric acid, counterstained with aqueous solution of methylene blue, and mounted in parolein."

A curved flagellum has been selected for reproduction in order to meet Dr. Eyre's criticism that the so-called flagellum was a smear from a slipped cover-glass. This flagellum, appendage, or whatever it may be called, of the Tubercle Bacillus was discovered by me in the spring of 1905 when examining a clinical mount for a medical practitioner. The stain in that preparation has faded away, but in other preparations the appendage has been seen by many microscopists, both trained and untrained, to whom others, as well as I, have shown it.

Slide 3.—The above are the first photomicrographs I have made since January 1902, but while my camera was set up the opportunity was taken of photographing a fascinating bit of broken secondary structure to test the photographic qualities of a Leitz apochromat $\frac{1}{12}$ of 1·4 N.A.

First you will notice that it is in black-dot focus, the silex being white. The black dot is the correct focus, for the white dot is a diffraction ghost, a function of the unutilised annulus of an object-glass. As this unutilised annulus is diminished by the enlargement of the axial cone the white dot vanishes away. In brief, white dots and narrow cones are synonymous terms.

Narrow-cone photomicrographs, showing white dots, are very easy to take (not more difficult than ordinary landscapes, for photomicrographic difficulties only begin with the large cone, and are then difficulties of a very serious nature), and when done are no test of the objective with which they were taken; this, therefore, has been photographed with a wide cone, and the magnification is × 4,000 diams. A Watson achromatic oil-immersion condenser was used immersed with all the photographs. Kindly note the fracture at the side of the cap; there are minute spikes which have been broken, four long and two short, while in the bridge piece the fractured spikes are of different lengths, and on the other side there are no long spikes at all. This very delicate structure may not be visible on the sheet, though on the lantern slide it is quite plain.

It will be in the remembrance of some present that in 1886, when Abbe introduced the apochromatic lens, he stated that in the high powers there were some outstanding errors which could not be removed in the objective itself, and that it was necessary to use an over-corrected (compensating) eye-piece to correct those errors. Further, in order that all the series of apochromatic objectives should be used with the same eye-pieces, intentional errors were introduced in the lower powers. Therefore it was the microscope as a whole that was apochromatic, and not the objective itself.

Now all this has been altered by Messrs. Leitz, who have produced a really apochromatic $\frac{1}{12}$, the performance of which is injured by the use of an Abbe over-corrected eye-piece.

If you examine the new compensating eye-pieces of Messrs. Leitz you will find the accustomed orange fringe at the edge of the diaphragm is no longer there. The microscopical world is all the richer for the introduction of these beautiful eye-pieces of Messrs. Leitz, as well as of the fine complanats of Messrs. Winkel.

NOTES ON A PHOTOGRAPH OF THE SECONDARY STRUCTURE OF *NAVICULA SMITHII.*

By A. A. C. Eliot Merlin, F.R.M.S.

(*Read March 26th*, 1912.)

Plate 22, figs. 3 and 4.

With reference to my communication to the Quekett Microscopical Club, read October 18th, 1907, on a certain new secondary structure of *N. Smithii*, I now submit for your inspection a non-critical small-cone photograph showing the structure in question sufficiently plainly to leave no room for reasonable doubt of its objective reality, should such yet exist in the minds of those familiar with the perforated capped primaries of other diatomic forms. The photograph (Pl. 22, fig. 3) was obtained at a direct magnification of 2,900 diameters with an apochromatic $\frac{1}{8}$ in. of 1·42 N.A. and an axial illuminating cone of 0·5 N.A. This exceedingly undesirable procedure was rendered necessary in consequence of the exterior surface of the valve being markedly convex, so that with a large cone it was found practically impossible to focus accurately more than one or two of the primaries on the camera screen; it therefore appeared allowable under such circumstances to bear in mind the adage that "half a loaf is better than no bread," and to invoke the aid of the small cone, which, you will see, has solved the difficulty by permitting a considerable area of the highly curved surface to be imaged with sufficient general accuracy for illustrative purposes. In some parts of the print the perforations are shown in white, and in others in black-dot focus. It is unfortunately true that the inherent defects of uncritical images are but too apparent to the trained microscopist, and thus the rendering of variations of size and shape of the secondaries leaves much to be desired when compared with the clearly shown visual critical picture, in which also the accommodating power of the eye makes some amends for the lack of the same quality in the objective. For purposes of comparison, a critical photograph of the *Coscinodiscus asteromphalus* showing secondaries × 3,300 is annexed hereto (Pl. 22, fig. 4) this form being sufficiently flat for such treatment.

I would earnestly impress upon the younger and more inexperienced members of our Club that, as a rule, photographs obtained under similar conditions to that of the *N. Smithii* are to be avoided by all who aspire to sound and good work, however fascinating their easy production may prove; for, given the necessary instruments and lenses, anybody with an elementary knowledge of ordinary photography, plus a few weeks' microscopical experience, can turn them out in quantities with ease and certainty, to the admiration of the unwary, for to such the picture of a diatom with the impressive contrast that reminds one of a new chess-board appears all that can be desired as the truthful representation of a highly translucent structure pierced by minute perforations and viewed by transmitted light! When the full, or nearly full, aperture of an oil-immersion objective is brought into play, and diffraction effects are reduced to a minimum, then the real difficulties commence, and are so formidable that few care to face them, especially as the results are only appreciated by the initiated.

Moreover, in spite of all the advantages of the small cone for those who like to photograph at ease, it is certain that pictures so obtained of unknown or uncertain structures should be received with the greatest caution; for although diffraction *may* occasionally be a good servant, it is more than likely to prove a bad master. Doubtful structures should invariably be confirmed by at least visual critical observation. Thus, in the case of *N. Smithii*, under the best visual conditions it is clearly seen that the primaries are pierced with holes of varying size and number,* and the non-critical photograph renders these coarsely, but with sufficient accuracy for record purposes, so that they may serve as a guide to what should be looked for and studied under preferable conditions. Were the valve as flat as that of the *Coscinodiscus asteromphalus* there would be no excuse, save sheer incompetency, for such a poor rendering. A great and very real danger with uncritical images is that, while wholly false diffraction effects may be mistaken for genuine detail, real structure of an unexpected or complicated character may be quite as probably overlooked or doubted. It is significant that the *N. Smithii* secondaries escaped detection for long, although lenses fully capable of revealing them existed; and although the form had attracted considerable attention it is likely that the secondaries were seen in uncritical images many times without their true nature being grasped, even though it might have been expected that a hint would be sufficient to any one familiar with the perforated capping of other diatoms.

In submitting these remarks and photographs I beg they may be taken as an addendum to my previous communication on *N. Smithii* (*Journ. Quek. Micr. Club*, Ser. 2, Vol. X. p. 247).

---

* *N. Smithii* valves examined vary considerably in size (from 0·15 mm. to 0·04 mm. in length), but all exhibit similar secondary structure.

Fig. 1.

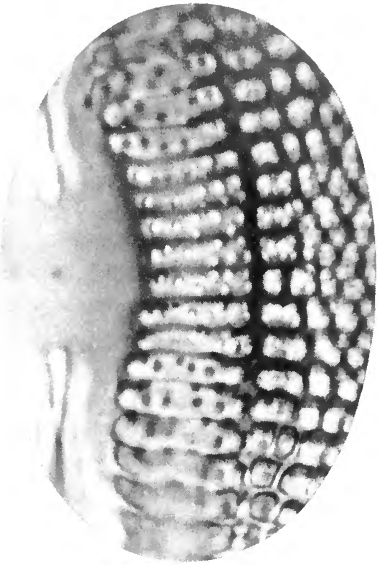


Fig. 3.

Fig. 2.

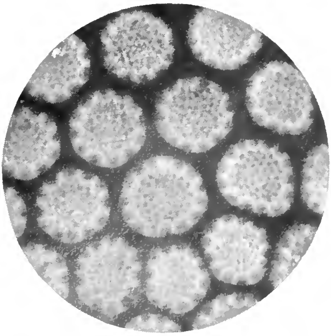


Fig. 4.

E. M. Nelson et A. A. C. E. Merlin, *photomicrogr.*

Illustrating Messrs. Nelson and Merlin's Notes.

NOTICES OF BOOKS.

Outlines of Evolutionary Biology. By Arthur Dendy, D.Sc., F.R.S. $8\frac{3}{4} \times 5\frac{1}{2}$ in., xiv + 454 pages, 188 figures in text. London, 1912: Constable & Co. Price 12*s.* 6*d.* net.

The interest taken in the rapidly accumulating results of biological investigation and the bearing of these results upon human problems, more especially questions relating to heredity and the kindred subject of eugenics, renders it necessary that the fundamental facts and principles underlying the study of biology should become more widely known. It is to meet this requirement that Prof. Dendy has prepared the above work, having in view not only the student of biology, but the reader who has had no special training in the subject. In the interests of the latter the author devotes the earlier chapters to the examination of two unicellular types—Amoeba and Haematococcus—and uses them to illustrate the structure and functions of plants and animals. He also deals in these earlier chapters with the nature of living matter and the chemical and physical properties of protoplasm. With this single exception the type-system is avoided altogether, and we can congratulate him in his departure from the stereotyped form in which the subject of biology has hitherto been treated. The present writer must confess that the chapters devoted to the evolution of sex, including therein the subject of sexual reproduction in general, have proved of the greatest interest. In dealing with this complex subject Prof. Dendy has shown great skill; for although technicalities abound, yet the whole is treated in a very lucid manner. It is also a pleasure to notice that many of the facts mentioned and the illustrations given have only recently been brought before the scientific world and are appearing here in a textbook for the first time. Part III. is devoted to the subjects of Heredity and Variation; and although the author is guarded in his statements, it appears that he is in sympathy with the view that "acquired" characters are capable of transmission to the offspring. As every reader knows, this question has given rise to much controversy during the last fifty years. "The fact that no satisfactory mechanism for the transference of such characters from parent to offspring has yet been demonstrated does not justify us in denying the possibility of such transference. Our decision must depend upon an unbiassed examination of the evidence which can be brought forward on each side." The latter half of the book is devoted to the theory and evidence, and the factors, of organic evolution, and here Prof. Dendy has again shown his skill, in the selection of a series of illustrative quotations, and the reader is enabled to follow the development of the theory of evolution in *ipsissima verba* of the teachers both before and after Darwin.

Most of the illustrations, of which there are nearly 200, are entirely new, but a few are redrawn from original memoirs. Extensive use has been made of photomicrographs; and in this connection we would again draw attention to the defects of this method, as compared with a drawing made direct from the micro-preparation, especially in the case of sections. The photomicrograph can only represent the detail in one optical plane, whereas a drawing may and often does represent details from several. Such figures as those on pp. 259 and 261 will convey little to the reader unless he be familiar with the preparations themselves.

THE BRITISH TUNICATA: AN UNFINISHED MONOGRAPH. By the late Joshua Alder and the late Albany Hancock, F.L.S., edited by John Hopkinson, F.L.S., F.G.S., F.Z.S. Vol. III., Aggregatae (*Ascidiae Compositae*). $8\frac{5}{8} \times 5\frac{1}{2}$ in., xii + 114 pages, 135 figures in text, 16 plates (14 coloured) and a frontispiece. London: Ray Society, 1912. Price 12*s*. 6*d*. net.

With the publication of this the third volume, the "unfinished monograph" of the British Tunicates is completed. Canon Norman, writing in the first volume, published in 1905, gives an interesting history of the work, telling us how on the death of Alder in 1867 and of Hancock in 1873 the MS. and drawings were entrusted to Huxley, who undertook to prepare them for publication. He, however, relinquished the task after four years' delay, and it was finally undertaken by the present Secretary of the Ray Society, Mr. John Hopkinson, who is to be congratulated on its completion. The monograph is described as "unfinished," and this is true, if only in the sense that the interesting pelagic forms, such as *Salpa*, *Pyrosoma* and *Appen-*

dicularia, are not dealt with at all. "But the fixed forms frequenting our shores are of more general interest, at least to the amateur naturalist, and this account of them renders fairly easy the identification of the species known at the time the authors wrote." Since their time the Tunicates have been transferred from their original position amongst the invertebrates, the Molluscoidea, to the Urochordata, the class containing the lowest type of Chordata.

Canon Norman writes (Vol. I., pp. x–xi): "All Hancock's admirable work was effected with the aid of such simple means as scalpels and needles; section-cutting and the use of chemical reagents were in his day unknown. Our author's custom was to gradually and most carefully dissect the animal, and to continually make new drawings as each fresh membrane was removed, thus mastering every detail, and then, aided by the numerous sketches before him, the finished drawing was produced." Of course with the minute forms this was done with the aid of a lens or microscope. The illustrations in the text are mostly reproductions of the earliest published figures of the species described. In addition we have sixteen plates, mostly coloured, nearly all the figures being from the original drawings by Hancock; a few, however, are taken from the beautifully illustrated monograph by Milne Edwards. By the kindness of the editor we are enabled to present to our members a reproduction of one of the plates illustrating this beautiful monograph. The species of Botryllus figured on Pl. 23 are as follows: *B. smaragdus* (1), *B. gemmeus* (2), *B. violaceus* (3–5), *B. badius* (6–9). A bibliography of the literature relating to the Tunicates is in preparation by the editor of this work and will be issued to subscribers as one of the volumes of the Ray Society for the current year.

MODERN MICROSCOPY. A HANDBOOK FOR BEGINNERS AND STUDENTS. By M. I. Cross and Martin J. Cole, 4th edition, revised and enlarged. $8\frac{1}{2} \times 5\frac{1}{2}$ in., xviii + 327 pages, 113 illustrations. London: Baillière, Tindall & Cox, 1912. Price 6*s.* net.

The publishers and authors are to be congratulated on the appearance of the familiar "Cross and Cole" in a fourth edition. In many ways it is a considerable improvement on the third edition, which appeared in 1903. The earlier chapters dealing with the construction of the microscope have been revised and added to, many new illustrations being introduced which represent the requirements of the present microscopist. We hardly think justice is done on p. 35 to the Greenough model of binocular instrument, which is being largely used in research work where only low powers and stereoscopic vision are required.

Considerable additions have been made in this edition to Part III., which is devoted to a series of articles by specialists dealing in each case with their own subject of research. This section cannot fail to be of very great service to the working microscopist. The first and most important addition is a very useful introduction to the use of the petrological microscope by F. C. Cheshire. The author explains the phenomena of polarised light and its application by means of the micro-polariscope to the examination of the sections of crystals, and further, the examination and identification of the constituents of rock sections. Mr. Rousselet has considerably added to his section on the collecting and mounting of the Rotifera, while Mr. Soar has given us the benefit of his experience in the study of the Hydrachnidae and Water Mites.

To the elementary student in the use of his instrument, and as a guide to further work, this handbook will continue to serve the purpose intended by the authors.

RECENT ADDITIONS TO THE LIBRARY.

Presented by Sir Ernest Shackleton:

British Antarctic Expedition, 1907–9.

Vol. I.	Part I.	On Collecting at Cape Royds	J. Murray.
	,, IV.	Musci	J. Cardot.
	,, VI.	Rhizopodes d'eau douce .	Penard.
	,, VII.	Freshwater Algae . .	West.

Presented by J. Murray:

Proceedings Royal Irish Academy: Clare Island Survey.

Vol. XXXI.	Part 37.	Arctiscoida . .	J. Murray.
	,, 51.	Rotifera . . .	C. F. Rousselet.
	,, 52.	Rotifera Bdelloida .	J. Murray.

Palaeontographical Society. 1853.

Fossil Brachiopoda.
Fossil Corals of Great Britain.
Fossil Shells of the Chalk: Cephalopoda.
Mollusca of the Great Oolite: Bivalves.
The Crag Mollusca—Continuation of Bivalves.
Fossil Reptilia of Great Britain, Wealden.

Purchased:

Diatomaceae of the Hull District. 1901.
Microbiology. Marshall, 1912.
Modern Microscopy. Cross & Cole. 4th Edition.

Textbook of Petrology	F. H. Hatch.
Petrology for Students	A. Harker.

Presented by The British Museum:

Mycetozoa. 2nd Edition	Lister.

Presented by Dr. M. C. Cooke:

One Thousand Objects for the Microscope. 1869.
A Fern Book for Everybody. 1867.
Vegetable Wasps and Plant Worms. 1892.
Romance of Low Life amongst Plants. 1893.

INTRODUCTION TO THE STUDY OF FUNGI. 1895.
HANDBOOK OF AUSTRALIAN FUNGI. 1892.
FUNGOID PESTS OF CULTIVATED PLANTS. 1906.
FREAKS AND MARVELS OF PLANT LIFE. 1904.
TOILERS IN THE SEA. 1889.

UNITED STATES GEOLOGICAL SURVEY:

MIOCENE FORAMINIFERA FROM MONTEREY SHALE OF CALIFORNIA.
BRYOZOAN FAUNA OF ROCHESTER SHALE.
DATA OF GEOCHEMISTRY.
THE COLLOID MATTER OF CLAY AND ITS MEASUREMENT.
THE ANALYSIS OF SILICATE AND CARBONATE ROCKS.
ANALYSIS OF ROCKS AND MINERALS.
THE SUPERIOR ANALYSES OF IGNEOUS ROCKS.
THE DATA OF GEOCHEMISTRY. 2nd Edition.

Presented by MR. A. R. HAMMOND:

STRUCTURE AND LIFE HISTORY OF HARLEQUIN FLY.

Presented by MR. A. EARLAND:

VARIOUS PAPERS ON FORAMINIFERA . Prof. Alfredo Silvestri.

Presented by the Author, PROF. ARTHUR DENDY, D.SC., F.R.S.:

OUTLINES OF EVOLUTIONARY BIOLOGY.

THE RAY SOCIETY:

THE BRITISH TUNICATA: AN UNFINISHED MONOGRAPH. Vol. III. 1912.
BRITISH DESMIDIACEAE. Vol. IV. 1911.

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the meeting of the Club held on October 24th, 1911, Prof. E. A. Minchin, M.A., F.R.S., President, in the chair, the minutes of the preceding meeting, held on June 27th, were read and confirmed.

Messrs. H. G. Brierly and O. W. Downing were balloted for and duly elected members of the Club.

The list of donations to the Club was read and the thanks of the members voted to the donors. The Hon. Secretary drew particular attention to a small microscope which had been presented to the Club by Mr. Hugh Paterson, of Sydney, N.S.W. This microscope had been given to the donor's father in 1850 by Prof. J. T. Quekett, F.R.S., M.R.C.S., the distinguished microscopist from whom the Club takes its name.

The Hon. Secretary read letters of thanks from M. C. Cooke, M.A., LL.D., A.L.S., in acknowledgment of the resolution passed at the previous meeting; also from the Misses Bywater, for the vote of sympathy passed at the same meeting on the death of their father, Mr. W. M. Bywater.

A paper communicated by Mr. E. M. Nelson, F.R.M.S., on "An Improved Compound Microscope by James Mann," was read by the Hon. Secretary. The author said that this microscope, which supplies three steps in the evolution of the modern instrument, was brought to his notice by Mr. T. Court. The instrument is figured on a plate in a pamphlet: "A Description of the Compound Microscope, with great improvements, London, made and sold by James Mann, at the sign of Sir Isaac Newton's Head and Two Pair of Golden Spectacles, near the west end of St. Paul's, 1751," which accompanies it. It is, in the main, obviously a copy of J. Cuff's (1744), the improvements consisting in the mirror and its attachment, and in making the instrument portable. The first portable compound microscope was made by George Adams in 1746, and in the instrument now described we see Mann's device for adapting Adams's idea of portability to Cuff's microscope. The name S. Johnson is engraved on the stage-plate, and it is almost certain that this microscope was the property of the celebrated Dr. Johnson.

Mr. C. F. Rousselet said the instrument described was not so substantially built as Cuff's. It was probably designed to be as portable as possible. In this case the stage is movable and not the body, as in Cuff's. It was a very interesting model.

Mr. C. D. Soar said that focusing by moving the stage is quite common in instruments of this date. Mr. Earland having suggested that Johnson was not a particularly uncommon name, and questioned the possible identity of S. Johnson with *the* Dr. Johnson, Mr. T. Court, the owner of the instrument, said that he bought it at Lichfield from a family who had had it for over one hundred years, and who bought it at a local sale of the effects of a friend of Dr. Johnson. All the accessory apparatus is complete and in good condition.

Mr. J. W. Shoebotham, N.D.A., gave "A General Account of the Spring-tails (Collembola)." He explained the position of the Collembola in the animal kingdom, describing them as belonging, with the orders Protura and Thysanura, to the sub-class Apterygota, of the class Insecta. After pointing out the main characters of these orders, the various parts of the Collembola were described more fully. Accounts were given of the eyes, post-antennal organ, pseudocelli, antennal organs, body, legs and those very typical collembolan organs—the ventral tube and the spring. Mention was made of the tracheal system, which is present but very poorly developed in a few species, but is absent in the greater number. In those species which have it in more or less rudimentary condition, the spiracles are to be found on the under side of the head.

A great variety of colour is exhibited by these insects, all colours from black to white being found. The order is interesting as containing one of the smallest known insects, namely, *Megalothorax minimus*, a species recently added to the British fauna, and which measures only 0·25 mm. ($\frac{1}{100}$ in.) The Collembola have generally been regarded as scavengers only; but recently considerable evidence has been brought forward to show that they may do considerable damage to growing crops. In Ireland they have been found feeding on the leaves of tobacco plants.

Collembola may be found in many situations, especially if they are moist; favourite places being under bark, stones, or sticks on the ground, under flower-pots in greenhouses, amongst grass, and on the surface of ponds. There are now between 400 and 500 species known. Finland has the greatest number of species recorded—163. Britain has 107, Germany and America 100 each, about 60 from the North Polar regions, and the same number from South Polar regions. In concluding, Mr. Shoebotham spoke of the dearth of British workers in this order, and hoped to find others interested in the subject, which, he was sure, would well repay the trouble. He referred to the increase in the number of species of Collembola recorded in Britain during the last few years, and saw no reason why many more species should not be added to the list if fresh districts were systematically worked. The subject was illustrated by numerous drawings, and specimens of the various generic types were exhibited.

The President said they had to thank the lecturer for a very interesting contribution to their knowledge of this group. These insects suggested many important questions for the morphologist, particularly in regard to the ocelli and their relation to compound eyes. Referring to the absence of wings, the President said that as all present insects either had wings or were descended from ancestors which had, this group, the Collembola, must be of extreme antiquity. They knew, for instance, of a cockroach with wings, of Silurian age, and the group they had just been hearing about must, therefore, date back very much further in its origin than that epoch. He hoped Mr. Shoebotham's remarks would gain some workers from the many ardent microscopists of the Club.

The thanks of the Club were unanimously voted to Mr. Shoebotham for his very interesting lecture and for the gift to the Library of two of his published papers on the Collembola.

Messrs. Watson exhibited an interesting series of mounts of embryos of Decapods.

At the meeting of the Club held on November 28th, 1911, Prof. E. A. Minchin, M.A., F.R.S., President, in the chair, the minutes of the preceding meeting, held on October 24th, 1911, were read and confirmed.

Messrs. J. Omer-Cooper, H. P. Elmsley, H. F. Nutt, A. Schmerl,

W. J. Martin and Dr. P. Guye were balloted for and duly elected members of the Club.

The list of donations to the Club was read, and the thanks of the members were voted to the donors.

The Hon. Secretary regretted to have to announce the death, on November 23rd, at his home in Bridgwater, of Mr. Arthur Cottam, F.R.A.S., who joined the Club in 1869. Mr. Cottam had devoted much attention to the study of the genus Aulacodiscus, and in the astronomical world his name is well known as the author of the series of star-maps issued under the title of "Charts of the Constellations" (1889). Mr. Earland said he had known Mr. Cottam at the time he lived at Watford. He was an excellent microscopist and a very skilful mounter, his chief subject being the Diatomaceae. He was perhaps better known as an astronomer, and had belonged to the R.A.S. for many years. He was also an excellent musician and a good painter. Like their late friend Mr. Jaques, he was connected with the Woods and Forests Department, and was a type of the best kind of Civil servant.

The death of Mr. J. Inderwick Pigg, F.R.M.S., who was well known to many present, was also announced.

Mr. C. Lees Curties (of Messrs. Baker) exhibited and described a small fitting designed to facilitate the illumination of opaque objects. It had been suggested by Mr. J. E. Barnard, F.R.M.S., and consists of a small right-angled prism affixed to an arm clamped to the nose-piece, which has universal movements. It is to be used with the microscope in the horizontal position, and the illuminating beam is thrown by a bull's-eye upon the prism. It is then projected through the diaphragm of the vertical illuminator, and so through the objective to the object. By this means the position of the vertical illuminator may be varied when objectives of different power are used without the beam of light being altered.

Dr. J. J. Simpson delivered a lecture on "The Relationship between Insects and Disease." He said that he might with equal, if not more, appropriateness have styled his remarks "The Inseparability of Insects and Disease." He proposed to deal almost entirely with tropical diseases, and would divide the subject into two headings: (*a*) The Mode of Dissemination, and (*b*) The Immediate Cause. In this second case, the study of unicellular organisms, Protozoa and Bacteria, the valuable contributions made by the President of this Club are too universally known to require more than mention on this occasion. Before proceeding further, the lecturer said he would like to pay a tribute to a late member of the Club, Mr. W. Wesché, whose pioneer work on mosquito larvae—the last work he was permitted to do—carried out under great difficulties, will ever stand out in the history of economic entomology. It is almost unnecessary to point out that in the animal kingdom no group is more intimately connected with the bionomics of the world at large than that designated by the general name "insects," and at the same time no group is so prolific in its effects both for good and evil. We can never forget the part played by insects in fertilisation, their utility as scavengers, their natural products (such as honey, wax, silk and colouring matters), and the effect of the gorgeousness of their subtle colouring on the aesthetic sense of man. Neither can we forget, for example, the destruction of crops by locusts, the effect of weevils on cotton and grain, the blight of vines by Phylloxera, and the injury wrought by ants and termites; but the dark side of the picture does not even end here. Who can forget the enormous annual loss of life and the infinite suffering to man and beast caused by insects, both directly and indirectly?—directly by themselves being the actual cause of the disease, indirectly by their mechanical dissemination of pathogenic bacilli, or by acting as intermediate hosts for other pathogenic organisms? The rôle played by insects in connection with disease is consequently threefold: (1) As actual parasites, (2) as mechanical transmitters, (3) as intermediate hosts of pathogenic organisms. In the first case—actual parasites—certain insects are themselves the immediate cause of disease, inasmuch as they pass part of their existence in the bodies of men and animals, usually beneath the skin, but occasionally in deeper tissues. This phenomenon is known as myiasis, and already over twenty species of diptera are known whose larvae have been found in, or expelled from, the human intestine. In such cases the ova of the insect have been swallowed with food on which they were deposited, and have continued their development in the alimentary canal, where they often give rise to strong inflammatory complications. Then we have the case of the screw-worm, the adult of which lays a mass of 300 or 400 eggs on the surface of wounds, in the ears or the nasal fossae. From these eggs the larvae are hatched in a few hours. They burrow in the tissues, devour the mucous membrane, muscles, cartilages, the periosteum, and even the bones, thereby causing terrible sores, and not infrequently, particularly when they attack the ear or nasal fossae, death by penetrating to the brain. The larval stage of another insect, *Cordylobia anthropophaga*, burrows into the skin of man and animals, and produces an inflamed swelling, from which it emerges after six or seven days. The lecturer then gave an example of an insect parasitic only in the adult stage. This was a flea, not unlike our common species, and almost universally known as the "chigger." It greedily attacks all warm-blooded animals, including birds and man. Until impregnated the female, like the male, is free, feeding intermittently as opportunity offers. So soon as she becomes impregnated the female avails herself of the first animal encountered to burrow diagonally under the skin, where, being well nourished by the blood, she proceeds to ovulation. By the end of this process the abdomen, in consequence of the growth of the eggs it contains, has attained the size of a small pea. During gestation the "chigger" causes a considerable amount of irritation, and, owing to this, pus forms round the distended abdomen. After the eggs are laid the superadjacent skin ulcerates, and the "chigger" is expelled, leaving a small sore, which, if infected by any pathogenic micro-organism, such as the bacillus of tetanus, may lead to grave consequences. As a cause of suffering, invaliding, and indirectly of death, it is an insect of no small importance. It was formerly restricted to the West Indies and America, but is now extremely prevalent in Africa, and on the east coast has caused a large amount of invaliding amongst the Indian coolies there, by whom it has been introduced into India.

Dr. Simpson then passed on to the consideration of the second group—namely, those insects which act as mechanical transmitters of disease. This process is simplicity itself, and, unfortunately, is not connected in any way with the life-history of the insect, nor with any special anatomical peculiarity. They simply act as vehicles of pathogenic organisms indiscriminately accumulated. An insect, by settling on a sick person or animal, or on their excretions, may pick up disease germs, either on the proboscis, wings, body or feet. Later on, the same insect alights on a healthy individual, or his food, water, milk, cooking utensils, and so on. Some germs become detached from the insect's body, and are thus conveyed from the sick to the healthy. In such a manner are cholera, typhoid and other diseases due to pathogenic bacilli spread by, for example, the common house-fly. This being now proved beyond doubt, the only solution is prophylaxis in the form of an organised wholesale destruction of this obnoxious pest, both in its adult and larval forms.

The third and most important group, that of insects which act as intermediate hosts, was then dealt with. The lecturer said that, while now the relationship between malaria and insects is looked upon as almost axiomatic, the mere name of the disease alone denotes that this was not always so. In 1894 Sir Patrick Manson definitely formulated a hypothesis on the subject. In 1895 Major Sir Ronald Ross began his now classic investigations; and in some cases by direct evidence, in others by analogy, in the year 1900 the theory had passed from the region of conjecture to that of fact. Ross in India, and others, including Grassi in Italy, traced the development of the malaria parasite from man through its various stages in the mosquito, back again to man; so that by the work of these and many other investigators the connection between mosquitoes and malaria was firmly established. An enumeration of some other diseases similarly transmitted was then given, and a list of the hosts responsible for their spread. To mosquitoes are due: (*a*) Yellow fever, (*b*) elephantiasis, and (*c*) dengue in man, (*d*) horse-sickness in the Transvaal, and (*e*) filariasis in man. The tsetse-fly is responsible for (*a*) sleeping sickness in man and (*b*) nagana in horses and cattle. The Tabanidae cause surra in cattle; Stomoxys, mal de Caderas in horses; Hippobosca, galzieht in cattle; fleas transmit plague; sand-flies, pappataci fever in man; ticks, relapsing fever in man, and Texas, Redwater, Rhodesian, Heartwater, biliary and other fevers in cattle, horses and sheep; spirochaetosis in fowls, and malignant jaundice in dogs. And who can say how many more?

Some remarks were then made on elephantiasis, plague, yellow fever, relapsing fever and sleeping sickness. In dealing with yellow fever, it was stated that so far all attempts to discover the actual parasite which causes this disease have proved futile; but, whatever may be the reason for this, it is practically admitted on all sides that it is a micro-organism, most probably protozoal. It is certain, however, that it is conveyed from one person to another by a mosquito. A few interesting points in connection with the mosquito and this disease are worth mentioning as showing how, by analogy, in spite of the germ never having been found, we may safely conclude that this is a protozoal disease, and that the organism most probably undergoes a change similar to that described for the malaria parasite: (1) Only mosquitoes which are fed on a patient during the first three days of the disease become infective—that is, are able to transmit the disease to another; (2) not until the twelfth day after the mosquitoes have fed on a sick person are these able to convey infection to a healthy individual; (3) such mosquitoes remain infective for at least fifty-seven days. Consequently, it is most probable that the organism undergoes a developmental process within the mosquitoes during the twelve days mentioned, and that the mosquito does not act as a mechanical transmitter, but as an intermediate host. Regarding relapsing fever, an interesting fact has been proved—namely, that the spirochaete may pass from a pregnant female into the egg, thence to the larva and to the adult, so that the progeny of infective ticks may themselves be infective without having previously bitten an infected person. Sleeping sickness is met with only in the Equatorial territories of the African continent, and, although it is practically certain that it is endemic on the west coast, it has slowly but surely crossed the Dark Continent, and by numerous epidemics this ghastly and terrible disease has destroyed whole villages in Central Africa with marvellous rapidity. It is practically always fatal, and the white man is equally susceptible with the black. It is caused by a protozoal organism in the blood, which eventually implicates the nervous system. The parasite is conveyed from the sick to the healthy by a dipterous insect universally known as a "tsetse." From the commencement of the infection to the terminal stage, there is reason to believe that in some cases an interval of years may elapse, though probably in the majority the march of events is much more rapid.

It is an old adage that prevention is better than cure, and enough has been said to indicate that in the subject under discussion prevention must be sought for on the insect side. These diseases can never be eradicated simply by medical treatment, and so long as the carrier exists, so long will the disease work its deadly way. It was pointed out that one of the first problems to be solved in this connection is the destruction of all blood-sucking insects—an enormous task, but one that is being slowly and surely accomplished. In the case of malaria, the successful methods adopted were due to the following line of reasoning: Anopheline mosquitoes have been proved to carry malaria. This insect feeds at night. As a first precaution, sleeping-rooms should be made mosquito-proof by having all openings covered with a fine gauze. Further, we know that these insects lay eggs in expanses of water, where, when hatched, they pass through larval and pupal stages, and finally emerge as adults. Consequently, to reduce the number of mosquitoes, an attack may be made on the immature stages. By systematic drainage the extent of the breeding-grounds may be reduced. When this is impossible, knowing that the larvae come to the surface to breathe, we can put a film of kerosene or other oil on the surface of the water, and kill off the larvae by blocking the breathing-tubes, and so on. In the case of yellow fever, carried by Stegomyia, it was found that the eggs are not laid in large expanses of water, as in the case of anophelines; but this insect prefers small collections, such as those contained in tin cans, broken bottles, or small earthenware pots. Consequently, a crusade was started to abolish all such receptacles. By this means, *Stegomyia fasciata*, with its attendant disease, yellow fever, has been practically banished from many places where previously it had a strong hold. Sleeping sickness is not such an easy problem, as we are not yet in possession of sufficient information as to the habits and life-history of the tsetse to attack this insect in the way which may eventually be possible. We know, however, that it is pseudo-viviparous. The female deposits an immature pupa, which burrows into the ground, and from which, after a time, the adult emerges. We also know that the mature insect must live in shade, near water. In Uganda this fact has been made use of in combating the disease. Villages near lakes where tsetse and sleeping sickness were abundant were removed to open, well-cleared ground, which the fly would not invade, and the result has proved an enormous success; in fact, it has probably saved the population of Uganda from absolute annihilation. Another method recently adopted with some measure of success has been the introduction into breeding-grounds or water of animals and fishes which are natural enemies of mosquito larvae. To the presence of a small fish called "millions" in the ponds of Barbados has been attributed the absence of malaria from that island.

Modern science has shown that nearly all diseases, directly or indirectly, are caused by germs. In many cases these germs have been discovered; in others they are yet to be found. In the majority of cases, disease germs are parasites, and therefore, to keep in existence, these species require to pass from host to host. Many require for their transmission from one individual to another the services of a third and entirely different animal. Whatever may have been the original source of the pathogenic parasites of man, it is certain that many which have a wide distribution at present were much more restricted originally. There is yet one factor which undoubtedly has contributed powerfully to delay the diffusion of certain protozoal Tropical diseases. It has been mentioned that most of these depend on definite animal intermediaries for their transmission. Although this necessity has undoubtedly operated powerfully against the spread of certain Tropical diseases, there is reason to believe that in time this difficulty will disappear. Two years ago the Entomological Research Committee for Tropical Africa was formed under the auspices of the Colonial Office (August 26, 1909). It consists of twenty members, including Sir David Bruce, Sir Patrick Manson and Sir John Macfadyean. All officers proceeding to take up appointments in Tropical African colonies now receive a short course of instruction in the fundamental principles underlying "Insects and Disease," and, as a consequence, many of these, by collecting and observing, have greatly added to the sum of our knowledge. The telling of this story is short and simple enough; but the hardships and difficulties encountered by the early pioneers must ever remain a sealed book. Many sacrifices have already been laid down on the altars of science; several brilliant investigators have succumbed to the subtle diseases whose secrets they have helped to elucidate —silent heroes whose names will never cease to live in the roll of the martyrs of science.

Dr. Simpson then exhibited a number of interesting lantern slides, photographs of some of the insects referred to, and of the type of country in Gambia where the tsetse is found, other views on the Niger, and several of mangrove swamps—which latter, he said, were real hotbeds for mosquitoes. A large number of mounted specimens of the insects dealt with were also shown.

Dr. Spitta said that Sir Patrick Manson was an early member of the Club—he did not know him personally, but his son knew him very well—and he had mentioned that his earliest interest in the study of insect life arose at the meetings of the Quekett Club.

The Hon. Secretary said that the earliest accounts of Filariae published by Sir Patrick Manson appeared in THE QUEKETT CLUB JOURNAL in 1880, having been sent by him to Dr. T. Spencer Cobbold, who communicated them to the Club, of which he was then President.

The President said he had listened with great interest to the paper which had been read that evening, which had touched upon an extraordinarily wide field. Noticing that in stables where fowls were kept there were very few flies, it occurred to him that as the pupae of the flies were usually found in loose earth, they were no doubt scratched up and destroyed in large numbers by the fowls, and he had suggested that fowls might be employed to keep down the numbers of the flies; nothing, however, came of the suggestion at the time. When he was in Uganda it was not known where the pupae of the tsetse-fly were to be found, but they were discovered soon after by Dr. Bagshaw, who found them in the loose earth in banana plantations. By a mere accident they were found on tree trunks, because the flies in that part could not deposit their eggs on the swampy ground bordering the waters. In the course of investigations as to sleeping sickness, the natives had been taught to look for these things, and on one occasion, when $\frac{1}{4}d.$ each was offered for them under the idea that perhaps 100 might be brought in, 7,000 were brought in the course of a few days. He suggested that the natives might be encouraged to keep fowls, such as the Indian jungle fowl, from which our own stocks were derived, as he felt sure that they would prove to be the most effective of the enemies of the tsetse-fly. In one place each coolie was made to wear a kind of fly-paper on his back, and in this way large numbers of flies were caught. It was also found that white clothing was a protection against flies, which settled in large numbers on black.

The thanks of the Club were unanimously voted to Dr. Simpson for his paper and for the exhibition of numerous specimens in illustration of the subject.

It was announced that no Ordinary Meeting of the Club would be held in December, as the fourth Tuesday would be the Bank Holiday.

At the meeting of the Club on January 23rd, 1912, Prof. E. A. Minchin, M.A., F.R.S., President, in the chair, the minutes of the preceding meeting, held on November 28th, 1911, were read and confirmed.

Prof. Arthur Dendy, D.Sc., F.R.S., the Rev. F. C. Lambert and Mr. E. G. W. Ryan were balloted for and duly elected members of the Club. Also Mr. Alpheus Smith (late Hon. Librarian) was elected to an honorary membership of the Club.

The list of donations to the Club was read and the thanks of the members voted to the donors. The attention of members may be drawn to nineteen slides of Freshwater Algae presented to the Cabinet by Mr. James Burton.

The Secretary read the list of the names of those who had been proposed by the Committee as President and Officers of the Club for the ensuing year, to be submitted to the Annual Meeting for election. Three members of the Committee who retired by rotation were Messrs. Burton, Inwards and Rheinberg, and if Mr. Akehurst was elected as Librarian, this would cause a fourth vacancy on the Committee. Members present were then asked for nominations of gentlemen to fill these vacancies.

The following were thereupon proposed for election at the Annual Meeting :

Mr. Burton,	proposed by	Mr. Wilson,	seconded by	Mr. Grundy.
Mr. Bestow,	,,	Mr. Burton,	,,	Mr. Davies.
Mr. N. E. Brown,	,,	Mr. Earland,	,,	Mr. Heron-Allen.
Mr. Offord,	,,	Mr. A. M. Jones,	,,	Mr. Hilton.
Mr. Inwards,	,,	Mr. O'Donohoe,	,,	Mr. Morland.

Mr. Wilson having been nominated as Auditor on behalf of the Committee, Mr. Hilton was proposed by Mr. N. E. Brown, seconded by Mr. J. Neale Ellis, and duly elected Auditor on behalf of the Club.

Mr. T. J. Smith, F.R.M.S., for Messrs. Watson, exhibited and described the "Spansa" Revolving Microscope Tray. He said the microscope is placed on a cloth-lined tray which has two extended arms connected by a circular block having on its under side a centre-pin. This pin fits into an oak base. The under side of the tray is fitted with "domes of silence," and can be revolved on the centre-pin, the lamp being placed on the wooden disc over the centre, and, revolving with the microscope, maintains its position constantly in relation to the instrument. The device allows of several people using the same microscope in succession with the minimum of inconvenience.

Mr. C. Lees Curties, F.R.M.S., for Messrs. Baker, exhibited a new three-lens dark-ground illuminator made to a formula by Mr. Nelson, and an improvement on his former two-lens model. It has a numerical aperture of 1·32, and works through a slip of over one millimetre thickness. Being provided with the universal thread, this illuminator can be used on almost any substage fitting.

A vote of thanks was passed to Messrs. Smith and Curties for their interesting exhibits.

Mr. James Burton read some notes on Freshwater Algae collected in 1911. Mr. Burton's notes had special reference to occurrences of the phenomenon known as the "breaking of the meres."

Mounted specimens of several of the species referred to were exhibited under microscopes, and the paper was also illustrated by coloured diagrammatic drawings.

The thanks of the meeting were voted to Mr. Burton for his paper.

The Hon. Secretary read a note by Mr. E. M. Nelson, F.R.M.S., descriptive of three high-power photomicrographic lantern slides sent, and then projected on the screen. The first was the eye-spot of *Coscinodiscus asteromphalus*, Maryland deposit, styrax mount, showing fracture passing through cap, × 3,000. Slide 2 was tubercle bacillus from sputum, showing the so-called flagellum × 4·150. The preparation was made in the middle of December 1911, by Dr. A. C. Coles, of Bournemouth, who gives the following particulars: "From sputum stained in ordinary way by Ziehl Neelsen's method, and decolourised in 25 per cent. sulphuric acid, counter-stained with aqueous solution of methylene blue, mounted in parolein." A curved flagellum has been selected in order to meet Dr. Eyre's criticism that the so-called flagellum was a smear from a slipped cover-glass. Mr. Nelson adds that this flagellum, appendage, or whatever one chooses to call it, was discovered by him in the spring of 1905 when examining a clinical mount for a medical practitioner. The stain in that preparation has now faded away; but in other preparations the appendage has been seen by many microscopists, both trained and untrained, to whom others, as well as he, had shown it. Slide 3 is of a fascinating bit of broken secondary structure, photographed for members' inspection, and also to test the photographic qualities of a Leitz apochromat, $\frac{1}{12}$ in., 1·4 N.A.

Mr. A. Earland, F.R.M.S., showed a number of lantern slides of Foraminifera which had been prepared to illustrate the principal types of rhizopod shell structure. Especial attention was directed to some abnormal specimens and transition types. Among the more noteworthy species shown were *Technitella Thompsoni* (Heron-Allen and Earland), *Webbina hemisphaerica* (Jones, Parker and Brady), and *Polymorphina concava* (Williamson). Some remarkable photographs illustrating fistulose Polymorphinae, both free and attached, were exhibited, and also a fine series showing triple isomorphism in the three genera, Cornuspira, Ammodiscus and Spirillina. The curious fossil genus Cycloloculina (Heron-Allen and Earland), found by the authors in the shore sands of Selsey Bill, Sussex, and as yet unknown from any other locality, was shown in its various stages of growth, and its affinities explained.

On the motion of the President a cordial vote of thanks was passed to Mr. Earland for the extremely interesting and beautiful photographs which had been shown.

It was announced that the meeting of the Club on February 27th would be the Annual Meeting, at which the Report and Balance Sheet would be presented and the election of Officers would take place. The retiring President would also give his address on that occasion.

At the meeting of the Club held on February 27th, Prof. E. A. Minchin, M.A., F.R.S., President, in the chair, the minutes of the preceding meeting, held on January 23rd, were read and confirmed.

Messrs. R. Jacobs, H. Palmer, G. E. Gammon, F. G. Wood, E. R. Tomlinson and C. C. Laverack were balloted for and duly elected members of the Club.

The list of donations to the Club was read, and the thanks of the members were voted to the donors. Special mention should be made here of a gift to the Cabinet of fifty slides by Dr. Eugène Penard, F.L.S., and a number of books to the Library by Dr. M. C. Cooke.

Mr. Ogilvy, for Messrs. Leitz, exhibited two examples of their new 2-mm. apochromat of N.A. 1·4. He employed × 25 compensating eye-pieces, giving a magnification of × 2,300. The definition of the objects shown, tubercle bacillus and *N. rhomboides*, was exceedingly good.

The President having appointed Messrs. Blood and Dunstall as Scrutineers, the ballot for Officers and five Members of Committee was proceeded with.

The Secretary then read the 46th Annual Report of the Club.

The Treasurer read the Statement of Accounts for the year 1911, and presented the Balance Sheet duly audited.

Mr. J. Wilson, in moving the adoption of the Report and Balance Sheet, thought the Club was much to be congratulated on its continued prosperity.

Mr. W. R. Traviss having seconded the motion, it was put to the meeting and carried unanimously.

The Scrutineers having handed in the result of the ballot, the President declared the following gentlemen to have been elected:

President . . .	PROF. ARTHUR DENDY, D.SC., F.R.S.
Vice-Presidents . .	C. F. ROUSSELET, F.R.M.S. E. J. SPITTA, L.R.C.P., M.R.C.S., F.R.M.S. D. J. SCOURFIELD, F.Z.S., F.R.M.S. PROF. E. A. MINCHIN, M.A., F.R.S.
Treasurer . . .	FREDERICK J. PERKS.
Secretary . . .	W. B. STOKES.
Assistant Secretary	J. H. PLEDGE, F.R.M.S.
Foreign Secretary .	C. F. ROUSSELET, F.R.M.S.
Reporter . . .	R. T. LEWIS, F.R.M.S.
Librarian . . .	S. C. AKEHURST.
Curator	C. J. SIDWELL, F.R.M.S.
Editor	A. W. SHEPPARD, F.R.M.S.

For Committee.

Vice four senior Members retired.	J. Burton. C. H. Bestow. J. M. Offord, F.R.M.S. N. E. Brown, F.L.S.
Vice S. C. Akehurst (apptd. Librarian).	R. Inwards, F.R.A.S.

The annual address was then delivered by the President, Prof. E. A. Minchin, M.A., F.R.S., taking as his subject "Some Speculations with regard to the Simplest Forms of Life and their Origin on the Earth."

Mr. D. J. Scourfield, in moving a vote of thanks to the President for his address, said he had given them an intellectual treat. During his period of office he had done them very great service, and it was a pleasure to know that they were not to lose him altogether, as his name still remained amongst the Officers of the Club as one of its Vice-Presidents. The chromatin theory led them to believe that the smallest forms of life were of the greatest importance, and they would have to look for still greater improvements in the microscope to enable them to perceive what was now beyond its powers. He had great pleasure in moving a very hearty vote of thanks to the President for his address, and requested him to allow it to be published in the Journal.

Mr. Bryce seconded the motion, and felt sure they would read the address with great pleasure and interest when it appeared in the Journal.

The motion, having been put to the meeting, was carried by acclamation.

The President said he thanked them for the kind way in which they had received his address, and also for the kind way in which they had treated him during the last four years. He should leave the presidential chair with still greater regret if he were not being succeeded by so able a man as Prof. Dendy. Dr. Dendy is Professor of Zoology in King's College, London, and has wide experience both as a professor of zoology and in research in various parts of the world. The President then introduced to the meeting his successor, Prof. A. Dendy, D.Sc., F.R.S.

Prof. Dendy, on taking the chair, said his first and very pleasant duty was to thank them for the very great honour they had done him in electing him as their President. Of course he had known the Quekett Microscopical Club by reputation for many years, but he felt he was taking upon himself a very great responsibility in following Prof. Minchin, more especially after listening to his address. Probably no one in England, he might say no one in Europe, was more capable of dealing with these subjects than Prof. Minchin. His trouble in the matter was that Prof. Minchin was really too good to be followed.

A vote of thanks to the Auditors and Scrutineers was proposed by Mr. Earland, seconded by Mr. Grundy, and carried unanimously.

Mr. A. D. Michael proposed a vote of thanks to the Officers and Committee. The Club was always greatly indebted to them for the large amount of time, attention and skill which they devoted to ensuring its prosperity, and he believed there was no society in which those services were more efficiently performed. He felt sure, therefore, that a vote of thanks to them would meet with the greatest approval.

Mr. Bremner said they had on hearing the report felt a mingled sense of thanks to their officers and congratulations to themselves, and especially they desired to thank the Officers and Committee, who had brought about the prosperity they enjoyed. They were very grateful to those gentlemen, and were showing their gratitude by asking them to continue their services for another year. He had much pleasure in seconding the motion.

Having been put to the meeting, it was unanimously carried.

Mr. Perks thanked the members, on behalf of the Committee, for the vote of thanks which they had just passed. He could only say that they had done their best in the past, and that they would try to do the same in future.

FORTY-SIXTH ANNUAL REPORT.

During the year 1911 there has been no outstanding feature of interest to chronicle so far as our Club is concerned. The number of new members added to the roll is only twenty-seven, and it is hoped that this reduction may soon be made good. The loss by resignation is, however, thirty-seven, and by death thirteen. The Club, therefore, has a smaller membership at the end of the year by twenty-three. No known reason can be assigned for the number of resignations, unless it be the Treasurer's reasonable request for payment of overdue subscriptions; your Committee is unable to ascribe it to any decay in the vitality of the Club.

The Club has to deplore the deaths of some of the older members, notably Mr. W. M. Bywater, who was one of the founders of the Club, Mr. G. K. Matthews and Mr. Arthur Cottam, both of whom joined in 1867.

The meetings have been well attended, and many interesting communications have been presented and discussed, amongst which may be mentioned the following:

Jan.	E. M. Nelson, On *Navicula Amicii.*
,,	C. F. Rousselet, On Three New Species of Rotifer.
,,	R. T. Lewis, On the Larva of Mantispa.
Feb.	E. A. Minchin, Presidential Address: Some Problems of Evolution in the Simplest Forms of Life.
March	E. M. Nelson, On Dark-ground Illumination.
,,	A. A. C. Eliot Merlin, On some New Diatomic Structures.
,,	Jas. Murray, On some New Species of Water-bears.
April	N. E. Brown, Notes on Seeds.
,,	D. J. Scourfield, On some Uses of the Centrifuge in Pond-life Work.
May	C. D. Soar, On the late Saville-Kent's Work on the Hydrachnidae.
,,	E. M. Nelson, On some Methods of Illumination.

June	E. Penard, On Two New Rhizopods from Sierra Leone.
,,	T. A. O'Donohoe, On Dimorphism in the Spermatozoa of the Flea and the Blowfly.
,,	E. M. Nelson, On Normal and Abnormal Vision in Microscopic Work.
Oct.	E. M. Nelson, On James Mann's Improved Compound Microscope (1751).
,,	J. W. Shoebotham, On Spring-tails (Collembola).
Nov.	J. J. Simpson, On Insects and Disease.

At the Ordinary Meetings of the Club the following slides and pieces of apparatus, etc., were exhibited :

Jan.	H. Gunnery, Slides and Photomicrographs.
Feb.	J. U. Bremner, Swing-out Substage Fitting.
March	A. C. Banfield, Improved Mercury Vapour Lamp.
,,	C. L. Curties, Nelson's Lamp and Dark-ground Condenser.
,,	M. Ainslie, Finder.
April	A. C. Coles, Bacteria, etc., mounted in Parolein.
,,	E. A. Minchin, Dissections of Rat-flea, etc.
May	T. W. Butcher, Photomicrographs of Diatoms.
,,	C. L. Curties, Slides showing Development of Trout.
,,	T. A. O'Donohoe, Photomicrographs of Test Objects.
June	J. W. Ogilvy, Leitz's Dark-ground Illuminator for Smoke Particles, etc.
,,	Watson & Sons, Slides showing Development of Chick.
,,	,, ,, Dissecting Microscope.
Nov.	C. L. Curties, Prism for Use with Vertical Illuminator.

Your Committee wishes to thank the Authors for their communications and the Exhibitors for bringing objects of interest to the notice of the Club.

The Curator has spent a great amount of time in the work of rearranging the Cabinet and amalgamating certain special collections with the general collection. As this has necessitated re-labelling, naming and cataloguing several hundred slides, it will be understood that the work has been tedious and laborious. The Petrological collection has been revised and some fine preparations added to it. It is hoped that some further illustrated and descriptive notes will be issued shortly similar to those already compiled by Mr. Caffyn. During the year 130 slides have been added to the Cabinet, of which seventy were presented, and a friend of the Curator and former member has promised a type collection of Hydrozoa. The Club now possesses 7,500 good preparations.

An interesting donation from Mr. Hugh Paterson, of Sydney, N.S.W., is a microscope which formerly belonged to Prof. Quekett and was given to the donor's father.

The thanks of the Club are due to the Curator for his great services, and to Mr. Bestow for his able assistance.

The Club excursions were nearly all favoured by extremely fine weather, but the absence of rain during the summer diminished greatly the amount of water, and many of the ponds towards the end of the season were completely dried up. There were ten excursions, the attendance averaging 16·7 members. As usual the visit to the Botanic Gardens, Regent's Park, showed the highest number, namely, thirty, and that to Higham's Park twenty-four. Owing to the ever-increasing difficulty of finding fresh places available for a visit during the short period of a Saturday afternoon, it is scarcely to be expected that new records will often be made. *Paludicella Ehrenbergi*, a freshwater type resembling in several points of structure the marine Polyzoa, was taken at Higham's Park; and *Cordylophora lacustris*, a freshwater representative of the Hydrozoa so common on the seashore, was obtained at the Surrey Commercial Docks. *Botrydium granulatum* was very abundant round a nearly dry pond at Hadley. The Committee desires to thank the authorities of the Royal Botanic Gardens, the Surrey Commercial Docks and the East London Waterworks for the facilities which they continue to afford to the members of the Club.

The accident which our former Hon. Librarian, Mr. Alpheus Smith, met with while on his way to the Club in April last was seen to be so serious in its effects that your Committee appointed an Assistant Librarian. As Mr. Smith was rendered physically incapable of continuing his duties, his resignation was accepted with great regret. Such service as Mr. Smith has rendered to the Club as its Honorary Librarian is unique in the annals of scientific societies, and the most sincere thanks of the Club are due to him for his great services.

In June the Committee appointed Mr. S. C. Akehurst as

Hon. Librarian with Mr. C. H. Caffyn as his Hon. Assistant. These gentlemen, with the assistance of Mr. Sheppard and Mr. A. Morley Jones, have overhauled the books very thoroughly. They have examined and checked carefully every volume. Since the last catalogue was published in 1904 about 330 volumes have been added to the Library, of which sixty-four are complete works and the rest are Periodicals, Proceedings, etc. Many of the latter were in parts which have since been bound.

To do this and to provide certain necessaries the sum of £35 has been granted by the Committee. Of this £29 has already been spent.

The work of the four gentlemen already named in classification and examination of parts for binding, in compiling a new catalogue, in labelling and arranging the collection of books, is deserving of the Club's best thanks, and your Committee desires to express its appreciation of the many hours of hard work done by them in the interests of the Club. For kind assistance with the Card Catalogue Messrs. Holder and Vogeler also deserve its best thanks.

Members will be given opportunities for examining the contents of many volumes of the Proceedings of other Societies which will be put on the table on Gossip Nights; and will be encouraged to make known the names of books which they consider should be in the library. Current numbers of periodicals and journals will be lent subject to prompt return.

A new catalogue of the Library is in preparation and will be issued as early as possible.

The Library now contains about 1,500 volumes, two-thirds of which are Memoirs and Proceedings of various Societies. The Librarian finds that five volumes are missing without hope of recovery.

This shows that the value of his predecessor's work is not to be reckoned only by the length of his forty years' service, but also by the close grip that he kept upon the details of his task.

The five missing volumes are as follows:

L. L. Clarke, Descriptive Catalogue of Objects for the Microscope.

Benj. Martin, Micrographia Nova (1742).

G. Murray, Phycological Memoirs, vol. I.

L. R. Tulasne, Mémoire sur les Lichens (1852).
D. B. Biasolette, Di alcune alghe microscopiche (1832).

Since 1910 the Library has received the following additions :

Quarterly Journal of Microscopical Science.
Annals of Natural History.
Botanical Gazette.
Essex Naturalist.
Victorian Naturalist.
Mikrokosmos.
Die Kleinwelt.

Memoirs, Reports, and Proceedings of—

Royal Microscopical Society.
British Association.
Royal Institution.
Geologists' Association.
Manchester Microscopical Society.
Manchester Literary and Philosophical Society.
Royal Institution of Cornwall.
Royal History Society of Northumberland.
Hertfordshire Natural History Society.
Bristol Naturalists' Society.
Birmingham Natural History and Philosophical Society.
Botanical Society of Edinburgh.
Glasgow Naturalists' Society.
Torquay Natural History Society.
Croydon Natural History Society.
Indian Museum (Calcutta).
Royal Society of New South Wales.
Natal Scientific Society.
American Microscopical Society.
Smithsonian Institution.
Academy of Natural Science, Philadelphia.
Missouri Botanic Garden.
Philippine Journal of Science.
Bergen Museum.
U.S. Department of Agriculture.
Lloyd Library, Cincinnati.
U.S. National Herbarium.

Some West Indian Echinoidea.
Report of Shackleton Expedition—Tardigrada.
Practical Microscopy (F. S. Scales).
British Lichens, Vol. II.

Your Committee desires to thank the Editors of the *English Mechanic* and *Knowledge* for the reports which they publish of the Club's proceedings. The former are sent to country members.

Your Committee desires to thank the officers of the Club for their services.

Finally your Committee would remind members that any falling off in the membership of the Club may be made good by encouraging new members and by their endeavours to make the meetings as useful, instructive and sociable in the future as they have been in the past.

THE TREASURER IN ACCOUNT WITH THE QUEKETT MICROSCOPICAL CLUB

Dr. *For the year ending December 31st, 1911.* Cr.

Dr.	£	s.	d.
To Balance from 1910	329	16	11
,, Subscriptions	253	0	0
,, Dividends on Investments	12	14	4
,, Sales of *Journal*	6	12	2
,, Sales of Catalogues	0	10	7
,, Advertisements	32	7	0
	£635	1	0

Cr.	£	s.	d.	£	s.	d.
By Rent, 1910	51	5	0			
,, ,, 1911	75	0	0			
				126	5	0
,, Expenses of *Journal*				101	9	5
,, Postages, etc.				5	14	4
,, Printing and Stationery				11	12	3
,, Attendant				6	3	6
,, Petty Expenses				22	19	4
,, Books, etc.				40	10	5
,, *English Mechanic*				5	4	0
,, Balance in hand				315	2	9
				£635	1	0

INVESTMENTS.

	£	s.	d.
2½ per cent. Consols	200	0	0
Metropolitan Water Board Stock	100	0	0
Metropolitan Consolidated Stock	100	0	0
2½ per cent. Annuities, 1905	100	0	0

We have examined the above Statement of Income and Expenditure and compared the same with the Vouchers in the possession of the Treasurer, and have verified the Investments at the Bank of England, and find the same correct.

February 13th, 1912.

J. WILSON
A. E. HILTON } *Auditors.*

FREDK. J. PERKS, *Treasurer.*

RESOLUTION WITH DARK-GROUND ILLUMINATION.

By A. E. Conrady, F.R.A.S.

(*Read March 26th*, 1912.)

Now that dark-ground illumination has acquired new importance for the observation of living bacteria, etc., some interest should attach to the question of the resolving power obtainable therewith.

It is, of course, well known that the chief uses of this kind of illumination do not aim at, or depend upon resolving power, but owe their value to the almost unlimited contrast which can be obtained against a black background. Cases must nevertheless arise where the resolution to be expected from any given combination enters as a factor, and in such cases the rules given below should be of some value.

The only theory which has been sufficiently developed to be able to solve such a problem is Abbe's. Even this can only deal with regular periodic structures which yield the well-known diffraction spectra; but for these the solution of the problem is extremely simple, as the theory supplies the proof that resolution is obtained when any two neighbouring diffraction spectra * are simultaneously admitted by the microscope objective, which leads at once to the postulate that the utmost possible resolving power of any objective is realised when two such neighbouring spectra occupy the extreme ends of a diameter of the objective. A

---

* The "direct" light in this connection is to be counted as one of the spectra—the central one.

further important and easily verified result of Abbe's theory is that with any properly constructed objective these diffraction spectra appear at perfectly equal distances from each other, no matter how they are caused to travel about in the clear aperture (by manipulating an oblique light stop, for instance), and that with any given objective their distance apart is directly proportional to the number of lines per inch of the structure causing them.

Bearing these facts in mind we compare the results obtainable

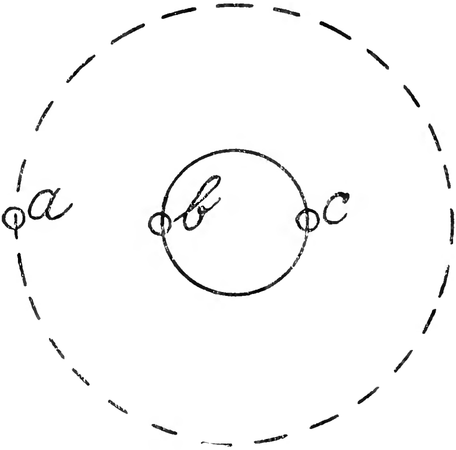


Fig. 1.

with dark-ground illumination with the limit theoretically attainable with direct light, *i.e.* when a ray of direct light just enters the clear aperture on one side, and the corresponding ray of the first diffraction spectrum at the opposite side as is shown in fig. 1, where the small circle represents the full aperture of an objective, *b* being the direct light, and *c* the first diffraction spectrum.

To proceed to dark-ground illumination, we will imagine that our objective is capable of being opened out to the aperture of the condenser to be used with it, thus enabling us to see the light coming from the condenser. We then ask ourselves: Can we realise the utmost resolving power just explained? The obvious answer is that we could if we managed to bring the first spectrum to the position *b* in fig. 1, when, owing to the equidistance theorem, the second spectrum would get into position *c*, thus realising the theoretical limit; but where does this necessitate placing the direct light? Evidently at *a*—as far from *b* as *b* is from *c*. Therefore the condenser must have an aperture at least as large as the outer dotted circle of

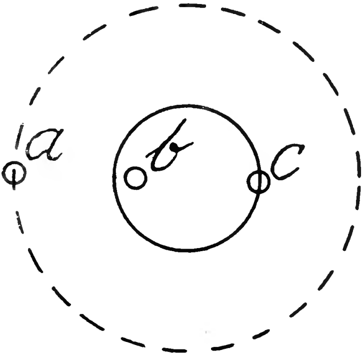


Fig. 2.

Fig 1, with a diameter obviously three times that of the inner circle; and as, again by Abbe's theory, these circles are proportional to the numerical apertures of the lenses or condensers, we arrive at the first result:

(1) In order to obtain the utmost resolving power with dark-ground illumination the condenser must have not less than three times the N.A. of the objective. As condensers are limited to say 1·40 N.A. this means that it is impossible to obtain their *fullest* resolving power with dark-ground illumination with any objectives over 0·47 N.A.

This immediately raises the question as to what resolving power *is* obtainable with objectives of greater N.A. than 1/3rd of that of the condenser. Fig. 2 supplies the answer. Again the full circle represents the aperture of the objective, the dotted circle that of the condenser. The best possible result will evidently be secured from light just entering the extreme margin of the condenser aperture as at *a*, with a structure of such fineness that the second spectrum only just gets into the farther margin of the objective at *c*. The first spectrum will be midway between *a* and *c*, at *b*, well within the aperture of the objective, thus showing the reduced resolving power. Now, we can at once see from the diagram that the distance from *a* to *c* is half the aperture of the objective plus half the aperture of the condenser; and as the distance from *b* to *c*, which measures the resolving power, is half of *a–c*, we obtain the second result:

(2) If a dark-ground illuminator has an aperture less than three times that of the objective, then the limit of resolving power of the combination is measured by one *quarter* of the *sum* of the numerical apertures of illuminator and objective.

Thus if we again work out a limiting case, we may take the limit of N.A. for the condenser at 1·40, that for the objective at 1·00, sum 2·40, and 1/4th of this or 0·60 will give us the N.A. of an objective which would have the same resolving power with extremely oblique direct light. In other words, under these conditions we should only realise 60 per cent. of the extreme resolving power of our objective.

There is another important result to be deduced from our diagrams. Take fig. 1, and assume that the condenser is fitted with a " wheel-diaphragm " approximately equal to its full aperture, so that the dotted circle represents the narrow ring of light which would pass through. The limit of resolving power would still be realised. But supposing we substituted an object a little *coarser* than the limit. The spectra would be closer together, with the result that whilst *c* would fall well within the aperture of the objective, *b* would fall *outside* it; there would be only one spectrum within the aperture, hence no resolution. It is not difficult to follow this up and to see that no structure coarser than the limit would be resolvable until we came to one having 2/3rds of the limiting number of lines, which would be resolved by the simultaneous entry of the second and third spectra. This leads to my third point—a new one, I believe:

(3) With dark-ground illumination it is important that the "wheel-diaphragm" should be only just large enough to secure a dark background, otherwise there may be certain ranges of structure which cannot be resolved, although both finer and coarser ones are visible.

I was led to the above investigation by a short paper by Mr. E. M. Nelson in *J.R.M.S.* 1908, pp. 671 and 672, dealing with the observational fact that "structures resolved (with a given objective) on a bright field may become invisible with dark-ground illumination," and which contained the statement—a challenge it appeared to me—that "the Abbe theory may be wrung up to its breaking-point, but not a drop of enlightenment can be squeezed out of it." Evidently Mr. Nelson did not squeeze it very hard. His paper, however, supplies a remarkable and welcome experimental confirmation of my theoretical results in the form of his first thesis:

"When periodic structures are examined with object-glasses having a N.A. of 0·35 and upwards, they should be placed upon a bright ground."

On the reasonable assumption that the underlying observations were made chiefly with dry condensers, it will be seen that this agrees marvellously with my first result, for theoretically 0·33 N.A. would be the highest with which full resolving power could be obtained over a dry condenser. With higher numerical apertures the bright ground would have the advantage.

Lest it should be thought that the little investigation dealt with in this paper was not original with me, I wish to say that the bare results as stated in the paper under (1) and (2) were communicated privately to a well-known author, and were, with my consent, embodied by him in a letter appearing in the January number of *Knowledge* (p. 37). As a matter of fact I revised the proof myself to make sure of a correct statement.

Botryllus spp.

NOTE ON *PROALES (NOTOMMATA) GIGANTEA* GLASCOTT, A ROTIFER PARASITIC IN THE EGG OF THE WATER-SNAIL.

By John Stevens, F.R.M.S.

(*Read April 23rd*, 1912.)

Plate 24.

In the summer of 1892 Miss Glascott discovered in Ireland, inside the eggs of the common Water-snail, a parasitic Notommatoid Rotifer which she named *Notommata gigantea*, and figured and described in her List of some of the Rotifera of Ireland,* but which, apparently, has not been observed since.

Early last year, in corresponding with Miss Glascott, she suggested I should keep a sharp look-out for Rotifers in the eggs of water-snails. I did so, and in June was fortunate enough to find several promising clusters of the eggs in the well-known jelly-like masses. There were plenty of the snails *Limnaea* (*Radix*) *auricularia* Linn. and *Paludina vivipara* Linn. present, so it is reasonable to assume that the former species was responsible for the eggs.

I could see at once that a considerable number of the eggs were infested with Rotifers. It was equally plain that with *Notommata gigantea* in mind it was not difficult to come to the conclusion that this animal was the same, which later was confirmed by Mr. C. F. Rousselet, to whom I sent some mounted specimens.

Miss Glascott's description of the general appearance and characteristic features of this species is quite good, but the figures are unfortunately inadequate, and do not give a fair idea of the creature.

There can be no doubt that this rotifer belongs to the genus Proales rather than Notommata, having much in common as

---

* *Sc. Proc. Roy. Dub. Soc.* Vol. VIII. (N.S.), 1893. Part I. pp. 29–86, 5 Pl.

regards shape, anatomy, and parasitic mode of life with *Proales Wernecki* and similar forms, and I therefore place it in this genus.

Supplementing Miss Glascott's description, the body of the adult is elongate, stout in the middle, and tapering at both ends; the anterior extremity is pointed, the ciliated face prone, extending ventrally as far as the mastax, the jaws of which can be protruded from the mouth situated within the ciliated area. The jaws are very small, of submaleate type, as shown in fig. 4.

The anterior region of the body, as far as the gastric glands, is hyaline, and the remainder, being distended by the vast alimentary canal and ovary, appears dark in colour and densely granular, rendering the posterior two-thirds of the body more or less opaque.

The stomach and intestine are voluminous in the adult, with large cells filled with granules. In young animals the stomach is very moderate in size, but seems to enlarge rapidly with growth.

The ovary is also very large, and usually contains one to three maturing ova. The ova are laid within the snail's egg, where they hatch in large numbers.

Three flame-cells on each side were observed, and also the small contractile vesicle.

The brain is a small hyaline mass, on which a very minute eye is situated. The eye consists of an exceedingly minute crystalline sphere, measuring no more than 3·4 μ (1/7500th of an inch) in diameter, to which a very minute and thin deep red disc is attached. In dissolving the Rotifer with potassium hydrochlorite for the purpose of studying the jaws, Mr. Rousselet saw the red disc separate from the crystalline sphere, both the structures resisting the action of the potash longer than the surrounding tissues.

The integument is very soft, showing four to five false segments or constrictions and numerous longitudinal folds. The foot is stout and short, terminating in two very small acute toes, whilst the body terminates in a minute, but distinct, tail-like appendage just above and between the toes.

Sense-organs, such as dorsal and lateral antennae, are no doubt present, but were not observed.

When in the compressor, without narcotic, the little Rotifer is constantly contracting, extending, twisting and turning, to the distraction of the observer, thus rendering observation difficult and tedious.

The newly hatched young is a small, cylindrical, stumpy, and lively person, swimming about briskly and having fully developed jaws in constant motion, as if practising this most important life-function.

The extreme size of an adult *Proales gigantea* measures 508 μ (1/50th of an inch) when extended. The toes measure 13·5 μ (1/1875th of an inch), and the small tail 68 μ (1/370th of an inch). The eggs are 102 μ (1/250th of an inch) long by 68 μ (1/370th of an inch) wide, and the newly hatched young measures 176 μ (1/145th of an inch) in length.

I am indebted to Mr. F. R. Dixon-Nuttall for the excellent figures illustrating this paper (Pl. 24).

As so little seems to be known of this parasitic Rotifer, I determined to place some under observation, and work out as much as possible of their life-history. This Club has always been interested in pond-life, so I have concluded that the following notes would be of interest to its members.

I started by placing good clusters of the snails' eggs in compressors, keeping them submerged in the trough, except when being examined under the microscope. I found this plan unsuccessful, for the Rotifers died in about two days, together with the embryo snail, although the water was kept fresh by the frequent use of the pipette. I then tried thin troughs, taking a cluster of eggs, not thick—that is, the separate eggs were not superimposed—and marked off seven, each one numbered on a diagram kept by my side during the days they were under observation. Notes were taken seven or eight times each twenty-four hours. All the eggs contained a good healthy embryo in almost constant motion, turning round and round in the fluid contents. Four of them were clean—that is, no Proales were present. The other three, Nos. 1, 6 and 7, had each one good, healthy Proales, as if just arrived, and the small hole of entrance could be seen. One I saw nibbling at the outside: a little later it had got just half-way in, and it was very interesting, even amusing, to see it wriggling through a hole which was much smaller than itself, and looking for some time as if it could neither get forward nor back. It took two hours to get inside. They are continually twisting and turning—never at rest. Miss Glascott's words are "ever rolling about and inverting the extremities, to the distraction of the student."

The Rotifer bites a very small hole in the tough egg-shell and bores its way into the snail's egg; it does not attack the embryo ferociously, but twists and turns in the fluid contents, and is evidently feeding on it, only occasionally nibbling at the embryo, which seems to take no notice, performing its slow revolutions as before. But all the same, damage is being done, and all signs of life have passed, in some cases, in two, and others up to seven and eight days.

As the notes are rather long, perhaps you will allow me to give particulars of No. 1 only, and take that as typical of the remainder.

First day, September 13th, 2 p.m. I see one Proales not full-grown; at 9.30 there is one egg; at 10.30 two eggs.

Second day, 7 a.m., there are seven eggs, 10.30 eight eggs; at 2.30 p.m. eleven eggs, and the first is showing signs of life. Five o'clock twelve eggs; at 8.30 the mastax of the first is plainly seen at work *inside* its own shell; at 10.30 it has become a well-defined Rotifer. There are now thirteen eggs, including the living individual noted on the first day.

Third day, 7 a.m. The parent has left, for "fresh fields," leaving a family of thirteen in all stages of development.

Eleven o'clock, all are giving signs of life, some by twisting themselves about strongly and others by simply twitching. Snail embryo dead and disappearing; 3.45 p.m., ten only remain; 7, seven only remain, the others having come to life and gone away. Several can be seen near by, in the jelly-mass, making their way to other eggs.

Quarter-past 9 p.m., two are still eggs, but show signs of life.

Fourth day, 7 a.m., seven still remain; 11.20, six only; 6 p.m., five remain.

Fifth day, 7 a.m., five still present, but not grown much, for it seems that not only has the snail embryo disappeared, but all the albuminous contents of the egg, intended for the sustenance of the young snail, has been eaten up by the young family of Proales; 2.30 p.m., four only remain, and these are poor things, looking quite starved, and clinging to the inside of the egg-shell instead of, as earlier, floating in the contents; evidently there is nothing left to feed upon.

From now to the thirteenth day, when these observations were brought to a close, these four remained, and were practically dead, although a little movement could be seen.

Now the question arises: What has become of the parent and young ones which left this egg? To answer this question I must refer to Nos. 2, 3, 4 and 5 on my diagram. No. 2 was not infested until the fourth day. No. 3 on the third. No. 4 on the second. No. 5 on the third day.

It is safe to assume that the Proales which left No. 1 were the same which reached the healthy Nos. 2, 3, 4 and 5. The course these ran was much the same as No. 1, with slight variations in number of eggs, viz. from seven to thirteen. I have seen some of the snail's-eggs absolutely stuffed full, counting over thirty, in all stages of development, but in those cases there were three full-grown animals, who were no doubt the parents.

As they leave the snail's egg they seem to flounder aimlessly about in the jelly-mass, but no doubt find comfortable quarters and good feeding ultimately. I observed, while mounting, that they were not at all "at home" while out in the open water. This is a true parasite, spending the whole of its life inside the snail's egg, with the exception of the time taken in scrambling from one egg to another.

It must not be supposed they all deposit their eggs and depart, for they must die somewhere. No. 6, although a strong-looking Rotifer, died on the third day, leaving nine eggs behind, and her remains were devoured, along with that of the embryo snail, by her progeny, the finishing touch being put by the appearance of a number of septic organisms on the sixth day.

The boring of the hole in the snail's egg-shell is not an easy matter, for it is very tough and resistant. So much so, that it was very difficult to break the shell (to get out the Proales); they persisted in slipping from under the needles. I found the best plan was to get the egg in the compressor, and gently screw down; it would then burst, and the Rotifers flow out. To show the toughness of the shell, the point of breakage was distinctly felt by the hands holding the compressor. The weed most favoured by the snails was the common Pond-weed (*Potamogeton natans*); the under side of the leaves. A good many occurred also on Anacharis.

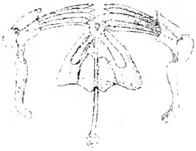
I desire to express my thanks to Mr. Rousselet for his great kindness in assisting me in the identification and minute description of this animal.

EXPLANATION OF PLATE 24.

Fig. 1. *Proales gigantea*, Glascott, dorsal side, × 100.
,, 2. *Proales gigantea*, ventral side, × 100.
,, 3. *Proales gigantea*, side view, × 100.
,, 4. *Proales gigantea*, the jaws, × 1125.
,, 5. Snail's egg, with *Proales gigantea* and ova inside, × 66.

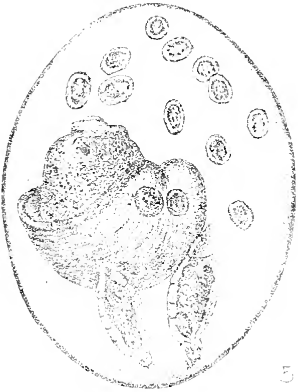
1.

2.



4.

3.



5.

F. R. Dixon-Nuttall del. ad nat. A. H. Searle, lith.

Proales (Notommata) gigantea, Glascott.

CRITICAL ILLUMINATION IN VISUAL WORK WITH THE MICROSCOPE.

BY DUNCAN J. REID, M.B., C.M.

(*Read April 23rd*, 1912.)

WHEN I was asked if I would read a paper on "Illumination in Visual Work with the Microscope," it seemed to me that to do so to the members of this Club would be almost superfluous. On further consideration, however, there occurred to me several reasons why, after all, the reading of such a paper might not be taken amiss. First of all, there are always a few beginners to whom it might be useful. Then again, there are many experienced microscopists who have not the time to devote to inquiries on the technique of illumination, who might even learn something, either from the paper itself, or from any discussion which might follow on it. Lastly, it must be admitted that there are still a good many disputed points even in connection with such a well-worn subject as illumination, and I thought that a discussion on these might be both interesting and useful.

I have confined my paper to the consideration of illumination in "critical work," by which I mean decisive or exact work. Every earnest microscopist has, at times, problems to solve, which demand all the perfection of apparatus and of technique that is obtainable for their solution, and perfect illumination is one of the most important factors in such cases.

I should like, however, in the first instance, to refer to a few precautions which enhance the effect of good illumination. All unnecessary and extraneous light should be avoided, and therefore one should have only as much light in the room as is absolutely necessary, and should certainly not face a window in daylight. The lamp should be shaded, so that no direct light from it is to be seen except that passing through the microscope. The observer should save as much as possible his best eye, when he is about to engage in critical work. Most microscope workers see more easily with one eye, usually the right, than with the other. For all adjustments of light, searching of the slide, and for all work that is not critical or difficult, the left eye should be used; or else the critical observation postponed till the good eye has recovered from its fatigue.

Another important aid is the use of complementary colour screens; green for red-stained objects, yellow for blue, and so on. The use of such colour screens will often enable one to see things which might be otherwise invisible, besides saving the eye considerably. At the Lister Institute, where much critical work has to be done, Professor Minchin uses a liquid green screen, consisting of a solution of a blue copper salt with picric acid. This cuts out much or all of the blue, and practically all the red, and if properly adjusted will also cut out the yellow, so as to give almost monochromatic results. It passes a considerable amount of light, and is very pleasant to work with. A very useful set of screens are the M screens of Messrs. Wratten & Wainwright, which give quite a number of useful combinations, but a blue-green, yellow-green, blue and yellow will be found sufficient for most purposes.

I propose to treat the subject of illumination under the following heads:

1. The most suitable light.
2. Collecting lenses.
3. The principles of correct illumination:
    - A. As regards the field.
    - B. Filling of the objective with light.
4. Condensers.
5. Distance of lamp from sub-stage mirror.
6. Critical and non-critical illumination.
7. Working aperture.
8. General arrangement of light and apparatus in high, medium and low-power work.

1. *The Most Suitable Light.*

For visual work, I believe the kerosene lamp to be best, at any rate for prolonged work. With a lump of camphor added to the oil in the well, and with both the edge and flat of the flame available, it fulfils every requirement. The lamp I use is one of those with a metal chimney, and a piece of glass in front, and with a Nelson lens on a swinging arm, on which it can be adjusted.

For critical work, the edge of the flame is best, as it gives a far brighter illumination than the flat, and therefore stands better the addition of screens. With the flat of the flame, however, one can obtain excellent results with low powers, and it is rather easier to adjust.

Using the edge of the flame, which I do myself with all powers, it is sometimes difficult to obtain, especially with low powers, absolutely equal illumination all over the field. To remedy this, I have made a slight modification of my lamp, which, if it has not entirely removed the defect, has certainly produced a great improvement. It consists in fitting to the inside of the lamp, quite close in front of the flame, and in fact in a line with its front edge, a thin metal plate, with an oblong opening, 3/8ths of an inch in width, and just a little less than the length of the flame. It cuts off the light coming from the posterior half of the flame which is usually taken up by the outer part of the collecting lens, and certainly gives very much more uniform illumination of the field, even with low powers.

The Nernst lamp is excellent for occasional and unusually difficult work, superior, I think, to the kerosene lamp, but it requires to be used with dense colour screens, and even then I find it too intense for continuous visual work. For dark-ground illumination it is perfect.

2. *Collecting Lenses.*

Although many workers say that for critical work they find the lamp flame, without the interposition of any collecting lens, best, personally I prefer the collecting lens, which becomes the source of light. This is placed near the lamp and focused so as to throw a nearly sharp enlarged image of the flame on the substage mirror; and the substage condenser, if then focused so as to produce critical illumination, gives us a sharp image of the partially closed collecting-lens iris on the field. If no collecting lens is used we have the field only partially illuminated, with either a bright streak or other form depending on the source of light. This I find very irritating, and much prefer the uniform illumination of the collecting-lens image.

As a collecting lens one may use an ordinary bull's-eye; but what is better is one like the Nelson lens, which gives much less spherical aberration. A lens I have found to give very good results as a collecting lens is Watson's macro-illuminator, which is a low-power achromatic substage condenser of 2-inch focus. The Zeiss collecting lens, on stand, is one which is rather extensively used; but it is of a much longer focus (4 inches) than the Nelson lens, and therefore requires that it and the lamp should be farther away from the microscope, to produce the same size of image of flame, than is necessary with the Nelson lens, which is only of 1 and 1/4th inch focal length.

It is better to have on the collecting lens an iris diaphragm, which facilitates the final adjustments.

Messrs. Zeiss have lately introduced a new form of Nernst lamp, with an aplanatic collecting lens with a shorter focal length, as far as I know, than any other on the market, which should be very useful where space is limited. It gives a very sharp image of the Nernst filament on the back of the substage condenser.

3. *The Principles of Correct Illumination.*

A. *Of the Field.*

As I have said, I prefer the field to be fully and uniformly illuminated, and it is quite possible to do this for all powers with the edge of the flame, even when critical illumination is employed, by the use of a collecting lens and a suitable substage condenser, without the aid of ground glass, which is sometimes recommended.

A 1. The *extent* of the *illumination of the field* depends:

1. On the size of the illuminant.
2. On the effective diameter of the collecting lens; and
3. On its distance from the microscope. The farther the collecting lens is away, the smaller the illuminated area of the field becomes.
4. On the *focal length* of the *substage condenser*. The higher the power of the condenser the smaller will be the image of the collecting lens in the field.

5. On the power of the *objective*. The lower the power of the objective the smaller, with the same condenser, will be the image of the collecting lens.
6. On the exact centring of light, collecting lens and condenser.

A 2. The *intensity* of the *illumination*—which, however, is of more importance in photomicrography—depends on several factors, but here I shall only refer to three of them:

1. The source of light (lamp or electric light, etc.).
2. With the kerosene lamp, whether we use the flat or the edge of the flame.
3. The use of coloured screens.

B. *The Filling of the Back Combination of the Objective with Light.*

It has been laid down by Abbe that the resolving power of an objective depends on its N.A. If this be admitted, one can understand how important it is that the result of the illumination should be such as to enable us to avail ourselves of the full N.A. Not that it is always possible to employ usefully the full aperture.

The filling of the objective with light depends on the following conditions:

1. That the *substage condenser* should be capable of focusing on the plane of the object a sharp image of the source of light, and should possess an *aplanatic aperture* at least as large as that of the objective in use.
2. That the sharp image of the illuminant, focused by the *collecting lens* on the mirror, should be large enough to fill the opening of the iris necessary to give us the full N.A. of the objective. (And here it may be remarked, that the farther the lamp and collecting lens are from the microscope, the larger will be the projected image of the edge of the flame.)
3. That the lamp, collector and condenser should be centred, as before described.

4. *Condensers.*

It is hardly necessary to say that without a condenser critical work, at any rate with high powers, is impossible. Even with the concave mirror, without a condenser the light is very feebie, and only a small part of the back of the objective is illuminated.

Moreover, an aplanatic achromatic condenser is advisable.

The *power and N.A. of the condenser* should be selected to suit the objective in use, *i.e.* it should be of about the same power, and of at least the same aperture. If of much too short a focus relative to the power of the objective, it may be difficult, if not impossible, to fill the field with light. If its N.A. is not at least equal to that of the objective, the full aperture of the latter cannot be filled with light. It may be necessary, unless a complete battery of condensers is available, to reduce the power of the high-power condenser by removing the front combination. This does not always give us a perfect condenser, unless it has been constructed to be employed in that way; but with those that I have so used I have obtained very good results. It is, besides, only with low powers that this has to be done.

It may here be observed that condensers of the continental type, with large lenses, are a little more troublesome to manage than the small English forms, as with the former the lamp and collecting lens have to be removed to a greater distance from the microscope in order to fill their full apertures with light.

5. *Distance of Lamp from Substage Mirror.*

It will be found that this has to be varied, according to the power and N.A. of the objective and substage condenser, and also according to the focal length of the collecting lens.

In photomicrography, where it is convenient to keep the lamp always at the same distance, the difficulty is got over by the use of supplementary lenses. This, however, would be inconvenient for visual work.

Keeping in mind that the nearer the lamp and collecting lens are to the microscope, the larger is the illuminated area of the field, and that the farther they are away, the larger is the image of the lamp flame projected on the mirror, and so available for filling the condenser, it is evident that we have to find a middle distance at which both field and back combination of objective are filled with light. It is quite common to see a man using an immersion objective with a large aperture, with his lamp and collecting lens only a few inches away. The field is fully illuminated, but, if the back combination were examined by removing the ocular and looking down the tube, it would be found, if he is using the edge of the flame, that it is only partially filled with light, and that with a streak image of the flame, if critical illumination is being employed.

It will be found that, with the Nelsen collecting lens, low-power objectives require the lamp to be quite close (4 to 6 inches from the mirror); medium powers (1/2 inch or 1/4th inch) from 6 to 12 inches; and high powers (1/6th to 1/12th) from 12 to 24 inches. With the *continental form of condenser* these distances would have to be increased.

6. *Critical and Non-critical Illumination.*

By "critical illumination" is meant that with the tube length properly adjusted, and cover-glass correction made, the *objective*, and the source of light by means of the *condenser*, are both focused on the same plane of the object. This arrangement has been recommended by the best authorities, as giving the very best possible results. It is, however, not uncommon to hear and see statements, by quite experienced microscopists, that "critical illumination" does not suit them, and that they can see nothing with it. This therefore deserves some consideration.

When we obtain, according to the above directions, so-called critical illumination, and the back combination is completely filled with light, it will be found that very few lenses—and that only with certain objects—will give perfect definition under such circumstances until the substage iris has been somewhat closed. When this partial closing of the iris has been carried out, just to the extent of giving perfect definition, we have got, as far as I understand the term, "critical illumination."

As I have said, there are some who say that they can see best with non-critical illumination, and I thought it would be interesting to carry out a few experiments, visually and photographically, to see how one compared with the other; with the result that when using a collecting-lens system of illumination, and provided that the same working aperture is used, critical and non-critical illumination apparently gave identical results. With non-critical it is easier to obtain uniform illumination of the field, especially with the low powers, whilst with critical it is imperative that the glass of lamp and collecting lens should be absolutely clean and free from spots, which may otherwise show on the field. In using non-critical illumination the iris of both condenser and collecting lens must be fully open, or nearly so.

Personally I prefer *critical illumination*, which when using a collecting lens is capable of giving us full N.A.; this the non-critical illumination may not do, and the former is easy to regulate by opening or closing the iris of the condenser. If any spots or imperfections on the collecting lens show on the field, I rack the condenser *very slightly* outside or inside the focus.

7. *Size of Aperture Employed = Working Aperture.*

As I have already said, few lenses give perfect definition with critical illumination at full aperture. The question then arises to what extent should it be cut down. Mr. Nelson, I understand, says that a 3/4th cone is usually the one which gives the best results. Some measurements which I have made tend, however, to show that the largest percentage aperture with which perfect definition can be obtained depends not only on the lens itself, but on the object, on the medium in which it is mounted, on the condenser and also on the system of illumination.

The best method of deciding when the aperture has been sufficiently cut down is to keep one's eye on the field and gradually close the iris until all flooding with light has disappeared.

Some objects such as blood films, bacteria, etc., will often stand the full aperture, whilst diatoms may require it to be closed considerably. Dry objects do not stand such a large aperture as those in balsam. The more perfect also the correction of the condenser, the larger the aperture that can be used without "flooding."

8. *General Method of Arranging Light and Apparatus for High, Medium and Low Powers.*

Having arranged the microscope at a convenient angle for work (with, say a·4 mm. or 1/6th objective, and fairly low ocular, a blood film on the stage, and a substage condenser of 1·0 N.A.) *the lamp* (with wick trimmed to give a well-shaped flame) should be placed about a foot away and directly in front, where it is more easily adjusted than at the side, and raised so as to be a little higher than the mirror. Having then roughly focused the object, we proceed as follows:

1. Centre the edge of the flame on the field, partly by means of the mirror, and partly by moving either the lamp itself or the microscope laterally.

2. Centre the substage condenser, by bringing the substage iris into view in the field, and centring it with the substage centring screws.

3. Having then opened the substage iris, focus the image of the flame again on the field, and re-centre it (see No. 1).

4. Adjust the collecting lens in front of the lamp, and focus it, so as to throw a nearly-sharp enlarged image of the edge of the flame on the surface of the mirror, keeping the collecting lens rather within than without the focus.

5. Close the collecting-lens iris, so as to let it show on the field, focus it, and centre it by moving the collecting lens from side to side and by raising or lowering it—taking care not to move the mirror or the microscope After which, the collecting-lens iris may be opened up.

6. If the *field* is not then fully illuminated, even to the extreme edge, the lamp is too far off, and must be brought a little nearer, or until the whole field is fully illuminated.

7. The ocular should now be temporarily removed, and the *back of the objective examined*, the substage iris being fully opened up for the purpose. If crossed by a streak form of illumination, the lamp and collecting lens are too near. If illuminated by a circular image, but not quite to the edge, the N.A. of the condenser is too small for that of the objective. If very bright in the centre and fading away in brilliancy towards the edge, the condenser is not aplanatic, or the collecting lens is not properly adjusted in relation to the lamp.

(Here I may remark that the objectives which are most difficult to illuminate, as described, are low powers with an unusually large N.A.)

Having adjusted the illuminating system, it will possibly be found that the object is flooded with light, and this must be corrected by cutting down the substage iris, as previously described.

Suitable complementary colour screens may now be introduced, and if the object to be examined only occupies a part of the centre of the field, the rest of the field may be darkened by partially closing the Nelson-lens iris, so as not to fatigue the eye by an unnecessarily large field. This, however, can only be done if critical illumination is being used.

For *oil-immersion objectives of high aperture* (above 1·0 N.A.) an *immersion condenser*, with a N.A. of 1·35 to 1·40, must be employed, and the lamp and collecting lens moved farther away from the microscope (24 to 36 inches or more), depending on the character of the condenser and on the focal length of the collecting lens.

For *medium powers* (1/2 to 1/4th inch) the dry condenser of 1·0 N.A. may again be used, the lamp and collecting lens being now, however, brought much nearer (6 to 12 inches), with Nelson lens and English form of condenser, and rather farther off than this for the continental form of condenser.

For low powers (2 inch to 1 inch) a low-power condenser must be employed, or the front combination removed from either the dry or the immersion condenser, and lamp and collecting lens brought as near as from 4 to 8 inches.

That concludes what I have to say. Of course in the scope of a paper, and in the time at my disposal, there are many things which have to be hurried over or omitted, but I would like, for the benefit of those who may wish more information on the subject, to refer them to Carpenter's work on the Microscope, and more particularly to Dr. Spitta's book on the same subject, where they will find the difficulties of illumination treated in a masterly way, both from a theoretical and from a practical point of view.

ON RESOLUTIONS OBTAINED WITH DARK-GROUND ILLUMINATION AND THEIR RELATION TO THE SPECTRUM THEORY.

By W. B. Stokes.

(*Read June 25th*, 1912.)

Serious students of Microscopical Images have long sought for a crucial experiment which shall decide the claims of the two theories which have been put forward to explain them. Dissatisfaction with the theoretical conclusions of Abbe and his supporters, and with their ideas with regard to the correct management of the microscope, caused many to look to the older theory propounded by Airy for an interpretation. Impartial authorities have, however, accepted Abbe's main results for the reason that it is almost impossible to illuminate a microscopic object without causing contiguous detail to transmit light-waves which, having a common origin and consequently a permanent phase-relation, are therefore in a condition to interfere. A crucial experiment will therefore appear difficult to make, and one would expect it to be made, if it is made, under conditions which do not occur in ordinary practice. Leaving aside the problem created by the use of a full or nearly full cone of illumination, the solution of which has yet to come, there yet remains one mode of microscopic vision which is distinctly practical, and at the same time seems to offer the very example which microscopists have sought. I refer to the image obtained with *dark-ground* illumination.

With this mode of illumination it is essential that the *direct light* shall not enter the objective. If the object has a periodic structure therefore, the so-called *dioptric beam* or *spectrum of the zero order* will not be included in the objective unless the object has some power of deflecting it by refraction or reflection.

Leaving aside the possibility of such deflection, it would appear necessary for resolution, if the Abbe spectrum theory is to be applied, that a spectrum of the second order should be included in the objective to co-operate with that of the first order.

Now, the inclusion of the second order spectrum may require considerable obliquity on the part of the incident light. Such obliquity, and consequently the resolving power of the objective, will be limited by the numerical aperture of the illuminator.

The arrangement of spectra formed by a plane grating can be determined by the equation

$$N = (\mu \sin u_0 - \mu \sin u_n)\, k/n,$$

where

N = number of intervals per unit of length in the object,
k = „ waves „ „ of light in air,
μ = refractive index of the medium,
u_0 = angle with normal by spectrum of zero order,
u_n = „ „ „ nth „

Assuming, as is usual, that the normal coincides with the optic axis, we may note two deductions of importance.

(1) Maximum resolution with dark-ground illumination will be obtained when spectra of first and second orders just enter the objective on opposite sides, that is

$$\mu \sin u_1 = \underset{\text{objective}}{(\text{N.A.})} = -\mu \sin u_2,$$

whence

$$\mu \sin u_0 = 3\,\mu \sin u_1,$$

That is to say, the N.A. of the illuminator must be three times that of the objective if maximum resolving power of the objective is to be obtained.* The resolving power thus obtained would be

$$N = 2\underset{\text{objective}}{(\text{N.A.})}\, k,$$

(2) Failing the condition (1) for maximum resolution the finest structures resolvable will be those which send a spectrum of the second order to the edge of the objective, the first order being easily included on the other side. In this case

$$\begin{aligned} N &= (\mu \sin u_0 - \mu \sin u_2)\, k/2, \\ &= (\underset{\text{illuminator}}{\text{N.A.}} + \underset{\text{objective}}{\text{N.A.}})\, k/2, \end{aligned}$$

the angle u_2 having a negative sign relatively to u_0.

Now, here we have a definite conclusion derived from the Abbe theory. Putting practicable values for the numerical apertures and the wave-frequency, it will be found that the fineness of

---

* This has been pointed out by M. I. Cross, *Knowledge* (p. 37), Jan. 1912. See pp. 477 and 480 *supra*.

detail resolvable with dark-ground by spectral interference is considerably less than with a wide axial cone. For example, let

$$\text{N.A. of objective} = 1{\cdot}0,$$
$$\text{,, illuminator} = 1{\cdot}35.$$
$$\lambda = 5{,}080 \text{ tenth metres}, \therefore k = 50{,}000 \text{ per inch.}$$
$$\therefore \text{N} = (1{\cdot}35 + 1{\cdot}0)\ 25{,}000$$
$$= 58{,}750 \text{ intervals per inch.}$$

A wide axial cone would be expected to resolve 75,000 or more with an objective of 1·0 N.A. and this light.

The Airy theory, in which resolution of details is considered as solely due to the contraction of the *diffraction patterns* or *antipoints* representing points in the object, would give with suitable objects a higher resolving power to objectives than follows this application of the Abbe theory, and it is this which makes a crucial test possible. If objectives will give better results than the Abbe theory will allow, then we are justified in turning to the older theory for guidance.

The first experiment which I made was with an old objective of 0·85 N.A. and a dark-ground illuminator of 1·35 N.A. This resolved a diatom known as *Navicula rhomboides* from Cherryfield, U.S.A., believed to have rows of perforations 60,000 to the inch. This result justified me in putting the matter of dark-ground resolutions into the hands of Mr. E. M. Nelson, whose unrivalled skill, experience and equipment have made him a referee in such matters. Through his kindness I have details of a great number of experiments, and I have been privileged to see many of the most important repeated by him. It will suffice, however, if I give a few of the results obtained with a Grayson ruling by the light of an oil lamp.

(*a*) N.A. Objective.	(*b*) N.A. Illuminator.	(*c*) Lines resolved in 1/1000 inch.	(*d*) Spectrum Theory ($\lambda = 5700$).	(*e*) *c*/*a*.
0·365	1·30	25	32*	68
0·490	1·30	35	40	71
0·660	1·30	45	44	68
0·735	1·30	55	45	75
0·860	1·30	60	48	70

---

* This was originally given as 37 instead of 32. I am indebted to Mr. J. Rheinberg for the correction.

From this table one may note:

(1) That column (*e*) shows that resolution with dark-ground is a function of the N.A. of the objective.

(2) That the last two results are well above the limit demanded by Abbe's spectrum theory.

If it be objected that resolution was effected by the shorter waves of the light used and not by the mean, I reply that the shortest useful wave-length would not give a theoretical result as high as that obtained in practice. The last three results were checked and repeated with a Wratten G screen, which is not intended to pass waves shorter than 5,100, and actually did not pass any shorter than 5,200. Supposing that this screen did pass waves as short as 5,080 the theoretical limit for the last objective would be

$$(1{\cdot}30 + 0{\cdot}86)\ 25{,}000 = 54{,}000 \text{ lines per inch},$$

which is still considerably below the result actually obtained.

If one is justified in adopting the mean wave-length (say 5,700) for calculation, then the last column agrees fairly well with the usual formula for the separation of two self-luminous lines, viz.,

$$\delta = \frac{0{\cdot}61\ \lambda}{\text{N.A.}}.$$

This agreement I believe to be more apparent than real. The sensible width of the lines on the ruling, and the uncertainty as to what resolution by contraction of antipoints really means, render exact agreement highly improbable.

It is not the mathematical computation of resolving limits which has prompted the publication of these results. It is the question of mode of resolution which I believe to be important. With the aid of mathematical physicists we may yet solve the problems which all microscopical images present, and to those solutions a study of dark-ground images cannot fail to be of the utmost use.

ON RESOLUTIONS OBTAINED WITH DARK-GROUND ILLUMINATION AND THEIR RELATION TO THE ABBE THEORY.

By Julius Rheinberg, F.R.M.S.

(*Read October 22nd*, 1912.)

The nature of the Image and the resolving power which is obtained with Dark-ground Illumination being a matter of considerable interest, I venture to make a few remarks on the interesting controversies which have taken place at the Quekett Meetings on the subject this year, since the discussions have, I am afraid, left the subject in an unsatisfactory state, which might give rise to misunderstandings and false impressions in the minds of many.

The course and main points of the controversy, shortly stated, have been as follows:

Mr. A. E. Conrady demonstrated, basing himself on the Abbe Theory, that *full* resolving power of an objective was only obtainable when the dark-ground illuminator had at least three times the numerical aperture of the objective—in other cases he stated it to be equal to one-fourth of the N.A. of the objective plus one-fourth the N.A. of the condenser.

Mr. W. B. Stokes urged that the latter proposition was not correct, that refraction by the object had not been sufficiently taken account of, and that higher resolutions were obtainable. In support of this he gave details of dark-ground resolutions obtained by Mr. E. M. Nelson, chiefly, I believe, on diatoms, and in a later paper gave a table of resolutions* obtained by Mr. Nelson with a Grayson ruling (which he had himself had the opportunity of seeing), which in a couple of instances showed resolutions 20 per cent. to 25 per cent. in excess of Mr. Conrady's limits. From which he inferred that the Abbe Theory was wrong as regards dark-ground illumination.

To Mr. Stokes's objections Mr. Conrady pointed out that the

---

* See p. 499 of current number of the Journal Q.M.C., and p. 504 of this paper.

Abbe Theory takes full cognisance of refraction as it deals with the subject on the broad principles of wave-motions, which include refraction and reflection as well as diffraction. On a later occasion he stated that the observational facts contradicted the suggestion that refraction accounted for the light scattered by diatoms, glass rulings, etc., but that diffraction, on the other hand, would fully account for appearances. He mentioned too that Abbe had described, thirty years ago, experiments to show that refraction could not explain the behaviour of microscopical objects. It could, however, alter the relative brightness of the diffraction spectra.

Lastly Mr. Stokes, on the strength of the resolutions obtained, claimed not only that they showed the Abbe Theory to be wrong, but that dark-ground illumination afforded a crucial experiment between the Airy and Abbe Theories, because under this illumination we could cause the points of the object to act as if they were self-luminous, whilst under ordinary illumination contiguous detail of the object would transmit light to the objective which was in permanent phase relation because it had a common origin. The Airy Theory, which predicted under suitable circumstances higher resolving power, was based on the former conditions, the Abbe Theory was based on the latter; hence the possibility of the crucial test. He contended that the results being in excess of the limits, we ought to turn to the older Airy Theory for guidance.

Mr. Conrady, in conclusion, considered the resolutions given by Mr. Stokes in very fair correspondence with his own limits, and laid emphasis on the difficulty of critically testing any theory. He pointed out how the number of lines per inch of a grating, the actual space ruled, any slight irregularities in the ruling as questions affecting the wave length of the light employed, make it extremely difficult to be sure one is working under the given conditions of a theory.

Although, much to my regret, I was unable to be present during the above discussions, and have therefore largely drawn upon the reports in the *English Mechanic*, I trust the short résumé given will be found impartial and correct.

Let us briefly see now where the above claims hold good, and where they are fallacious or give rise to misconceptions.

Mr. Conrady's first demonstration, viz. that the *full* resolving power of the objective is only obtainable with dark-ground illumination when the illuminator has at least three times the numerical aperture of the objective, is common ground acknowledged by all. His second proposition, that in other cases it is equal to one-fourth the N.A. of the objective plus one-fourth the N.A. of the condenser, is a wonderfully simple and elegant deduction following from the laws of the Abbe Diffraction Theory; but it would seem that he has not made it sufficiently clear that it applies solely to an ideal object, such as an homogeneous film of alternate dark bars and clear spaces, which does not refract the light transmitted through it. Refraction of light simply denotes that the direction of main intensity of the light is shifted; and whilst it is perfectly true that such alterations of the passage of light are fully covered by the Abbe Theory, which deals with the subject on the broad principle of wave motions, Mr. Conrady's limits postulate an absence of change in the direction of chief intensity of the light, or, in common parlance, of refraction. It is indeed one of the main features of interest of Mr. Conrady's demonstration, that it brings out and draws attention to the fact that even though there be an entire absence of refraction by an object, it might nevertheless yield a well-defined image by dark-ground illumination. As dark-ground images are popularly so much associated with refraction phenomena, that fact will probably have been new to a good many microscopists.

This said, it will be seen that we must agree with Mr. Stokes that for practical purposes Mr. Conrady's limits do not hold good; indeed, the table of resolutions obtained with the Grayson ruling is in itself conclusive evidence of this. I may say that I have myself repeated the experiments with the Grayson ruling, and obtained results in sufficiently close accordance with the table given. The excess of resolution beyond Conrady's limits is too great to be easily accounted for by errors in the ruling, and the other matters he has adduced. The inference from the table of resolutions is simply that refraction as such does play an important rôle in dark-ground images, although it will not explain the images by itself. This might indeed have been anticipated; the results afforded the experimental proof.

It must not, however, be assumed from this that Mr. Conrady's limits are of no value. On the contrary, they are of the greatest interest, for taken in conjunction with Mr. Nelson's results they enable us to get a very good idea of the relative rôle which refraction plays in dark-ground images. Clearly if Mr. Conrady's limits hold good without refraction, and we are able to obtain results in excess, we have but to deduct the one from the other to enable us to judge how refraction as such is acting.

Now this brings out a striking fact which reference to Mr. Stokes's table, reproduced here in part, shows:

(*a*). N.A. Objective.	(*b*). N.A. Illuminator.	(*c*) Lines resolved in $\frac{1}{1000}$ in.	(*d*) Conrady's limits ($\lambda = 5700$).	Difference between (*c*) and (*d*).
0·365	1·30	25	32	− 22 per cent.
0·490	1·30	35	40	− 12 ,,
0·660	1·30	45	44	+ 2 ,,
0·735	1·30	55	45	+ 22 ,,
0·860	1·30	60	48	+ 25 ,,

From the last column, added by myself, it will be seen that the percentage steadily increases with increased ratio of the N.A. of the objective to that of the illuminator. In other words, given the same illuminator the effects of refraction as such are increasingly in evidence the higher the power of the objective. This I believe to be a fact which has not hitherto been recognised.

Personally I am inclined, indeed, to assign an even greater proportion of the effects obtained in dark-ground illumination to refraction than is brought out by the above table, for the reason that we never do in practice obtain the full limit of resolution which theory predicts. Moreover, it will be seen that with the first two low-power objectives mentioned above results are obtained much below Conrady's limits, although we know that if the object is refracting light in the case of the last three examples given it will also be doing so in the first two examples.

We may, I think, attribute this deficiency in resolution in the first two cases, where the illuminating cone is excessive compared with that of the objective cone, in great part to the same causes which bring about a loss of detail "by flooding out" in the case of ordinary transmitted illumination when we use an illuminating cone larger than the objective will stand. I do not enter into this question more fully here, as it is a side issue which does not affect the main points which I wished to bring out.

We come now to Mr. Stokes's contention that his results are not in accordance with the Abbe Theory, that they show it to be incorrect as regards dark-ground images, that dark-ground illumination affords a crucial test between the Abbe and Airy Theories, and justify us in turning to the latter. These propositions are one and all based upon misconceptions; not one of them will stand examination.

The dark-ground effects as obtained in practice can be explained, dealt with and predicted readily enough by the Abbe Theory, but I do not purpose wearying those present by entering into any elaboration of this, as it would need a technical paper by itself. For present purposes it suffices to point out once more what I am sure will not be denied by Mr. Conrady, that his formula—Dark-Ground Resolving Power = $\frac{1}{4}$ N.A. of Objective + $\frac{1}{4}$ N.A. of Illuminator—postulates that the direction of the main intensity of the transmitted diffraction fans suffers no change in its passage through the object, and that if this—and the change in the light intensities in other directions which is consequent upon this—did take place, additional factors taking the intensity changes into account would have to be dealt with. Or, stated shortly, absence of refraction is assumed in the formula itself.

Next, as regards object points illuminated by dark-ground illumination not being in permanent phase relation, and therefore behaving as if self-luminous, surely Mr. Stokes will agree that if under ordinary illumination the light focused on the object points by the illuminator is such that contiguous detail transmits light having a common origin and therefore in permanent phase relation, that fact is not changed in any way because dark-ground illumination is resorted to. All that is changed is that in the latter case some other parts of the light fans from these object points impinge on and are transmitted by the objective, but that does not touch the question of permanence of phase relation at all, even if there were any alteration in the phase relations themselves.

We see, then, that dark-ground illumination is far from affording us the conditions of self-luminosity, and Airy's investigations dealt only with self-luminous objects, and were, as was pointed out by Mr. Conrady, and recognised by Mr. Stokes, never carried beyond the determination of the forms of star images.

Summing up, it will be seen that whilst the controversy has not afforded any evidence whatsoever against the famous Abbe Theory of Microscopic Vision, it has brought out, firstly, that we can have dark-ground effects without refraction; secondly, that under practical conditions refraction certainly plays its part; and lastly, it has afforded data which throw new light upon the extent of the part which refraction plays under different conditions of aperture of the objective and illuminator.

NOTE ON *SOLPUGA FEROX.*

By R. T. Lewis, F.R.M.S.

(*Read May 28th*, 1912.)

The fifth order of the Arachnida, the Solifugae, consists of three families, of which the *Solpugidae* is the second. This again is divided into five sub-families, the second of which, the Solpuginae, contains two genera, Solpuga and Zeriana, Solpuga comprising about fifty species, all of which are African. In general appearance they are formidable-looking creatures varying in length from one to two inches, and in colour from reddish brown to dull grey. They are covered with hairs of several distinct kinds, are very rapid in their movements, and nocturnal in their habits; they are armed with two pairs of enormously developed chelicerae placed near together side by side, and opening vertically, and they have two large, simple eyes, close together, upon the front part of the cephalothorax.

The specimen which is the subject of this note was sent to me from Lindley, in the Orange Free State, by one of our members, and together with some allied species from Natal has proved of so much interest as to warrant some description being given to the Quekett Microscopical Club.

The length of this Solpuga is 1·5 inch measured from the extremity of the chelicerae to the end of the abdomen; but its resemblance to a spider, which would be at first remarked, disappears on closer inspection, inasmuch as the cephalothorax is formed of six segments, the first three being fused together, and the others separate and movable, whilst the abdomen is divided into ten distinct segments formed of dorsal and ventral plates as in insects, and the spinning organs are entirely absent. The powerful chelicerae are two-jointed, very sharp, and smooth at their curved extremities, but irregularly toothed on the edges, which meet together when closed; the basal portion of each is furnished with a row of stiff spines, and the inner surface of the toothed portion is thickly lined with plumed hairs, whilst the whole, except the curved extremities, is closely covered with hairs, some of which are simple and tapering, and others of equal thickness throughout, until at the ends they widen out and terminate in two points resembling the inverted barbs of an arrow-head. The large expanded bases of the chelicerae are occupied by strong, striped, muscular fibres, which form a fine object when viewed by polarised light. Though the double bite inflicted would undoubtedly be severe, there is no evidence that it is poisonous; dissection and careful microscopic examination fail to detect the presence of any poison gland or duct, or of any perforation in any part of the chelicerae such as would be found —as in the case of spiders—if poison were injected into the wound at the moment of penetration.

On the dorsal surface near the extremity of each chelicera in the male there is a curious organ known as the flagellum, curving backwards, and ending in a spear-shaped point, the function of which is problematical; it is common to all the male members of the first three sub-families of the *Solpugidae*, but differs considerably in shape in different genera.

A casual observer would suppose that a Solpuga had ten legs, of which the first and last pairs were longer and stronger than the three pairs between. The first pair of these lateral appendages are, however, the pedipalpi, consisting of six joints, the first three of which are short, and the others of nearly equal length, extending altogether over 1·5 inch. They are thickly covered with hairs, many of which have bifid ends, as already described; others rather thicker end in a rounded knob, these are finely cross-striated, and contain what appears to be a nerve; a third kind is simple and pointed; and in addition to these are a number of long silky hairs widely extended on either side with a sweep of nearly two inches. The extremity of each pedipalp is slightly expanded and rounded, and contains a curious sense-organ, which can be protruded at will, but when not in use is concealed within a lip-like covering. The precise nature of this is not known; it is regarded by some as suctorial, and by others it is thought to be an organ of smell; but as it bears some resemblance to a retractile organ found on the extremity of the palpus of a Tick, it is possibly of analogous function.

The first pair of legs are six-jointed, but differ from the others in being more slender, and without claws or divisions in the tarsus; they are rounded at the ends, and terminate with a close tuft of short hairs, and are covered throughout their length with hairs of the four kinds found on the pedipalpi. These legs do not appear to be used for walking, but are generally carried high up from the ground when the creature is in motion.

The second and third pairs of legs are nearly alike; they are six-jointed; the tarsus is divided into one long and three short joints, with the addition of two long terminal claws. The tarsus and the joint immediately above it are armed with strong spines, the claws are long and smooth, but are peculiar in being themselves jointed near their extremities. As in the case of the first pair of legs, they are profusely covered with hairs, both bifid and pointed, some of the latter being extremely fine and of great length, but the knobbed variety is absent.

The fourth pair of legs are very remarkable; they are much longer and stronger than the others, and are differently divided, having eight joints exclusive of the divisions of the tarsus, which has one long and six short joints in addition to the claws, which, like those of the second and third pair of legs, are also jointed near the ends. The under side only of the tarsus is armed with spines, and the whole leg is covered with hairs, some of which are very long, extending far beyond the stretch of the legs, but the knobbed hairs are not present. Three out of the four joints next to the body have five curious fan-shaped organs suspended from them in a crosswise direction by flexible stems, which connect them with the tracheal and nervous systems of the creature: these are the malleoli. In size they vary considerably, according to that of the bearer, their average breadth at the widest part being about 1/15th of an inch, the stem being about 1/25th long by 1/75th of an inch in diameter. Being very translucent and almost colourless, it has been difficult to make out their structure, especially as their refractive index is nearly the same as that of glass or Canada balsam; staining has not been of much assistance, and they are all but invisible under a polarised light. It happens, however, that the malleoli of a Solpuga sent to me in glycerine, after having been washed and mounted in balsam, are much more satisfactory objects for examination, appearing of a chrome-yellow colour on the slide, and showing the internal structure far better than any which have been mounted in other ways. They appear to consist of two membranes united at their edges and containing a number of obvious trachea which branch and subdivide in all directions from the point where they emerge from the stem, and in addition to these there are numerous filaments which pass down the stem in a bundle and spread throughout the fan in a dense plexus. The convex lower edge of each fan is bordered with fine vertical striae about the 1/10,000th of an inch apart, and immediately above these is a row of curved markings running in a nearly horizontal direction, giving the appearance of a double border. There is, however, more than a suspicion that there are a number of minute openings all along the outer edge about the 1/1,000th of an inch apart, since the contraction of the balsam, and consequently the increased pressure on the surfaces of the malleoli, has expressed a number of globules of glycerine which look like a row of beads along the margins of these particular specimens.

Unless it be with the curious organ—the pecten—found on the under side of the Scorpions, the malleoli seem to have no analogy amongst the ARACHNIDA, and the special purpose they are intended to serve is one concerning which we certainly have no actual knowledge. Some writers simply refer to them as "sense organs," without risking any guess as to what that sense may be, others have thought them to be organs of touch; but it would ill become us to restrict their use to any one sense, and merely to assign them to a tactile sense which seems amply provided for by the pedipalpi, the first pair of legs, and the extended hairs with which every appendage is furnished.

Experiments with the vibrations of light and of sound lead one to the belief that there may be vibrations beside those to which our own sense organs respond, and it may be that the malleoli are tuned to vibrate in unison with such impulses, conveying to the Solpuga information as to the whereabouts of its fellows, its enemies, or its prey.

The following preparations were exhibited in illustration of the above paper: (1) Extremity of a pedipalp. (2) Extremity of first leg, showing striated hairs. (3) Extremity of second leg, showing jointed claw. (4) Fourth leg, showing the malleoli in position. (5) One of the malleoli, more magnified. (6) Hairs from the inner surface of chelicerae.

NOTES.

THE ROUSSELET COMPRESSOR.

By E. M. Nelson, F.R.M.S.

(*Read March 26th*, 1912.)

Although my microscopical work is mostly concerned with mounted objects, yet living and other specimens which happen to come in my way are often examined, for which purpose the Rousselet compressor is invaluable. There are two small faults to be found with this compressor; but as both may easily be remedied they do not much matter.

The first is that when my rotating (double) nose-piece is put into action, unless the microscope body is first racked up by the coarse adjustment the front lens of the objective, which it is intended to use, comes into contact with the edge of the milled head at the top of the screw-post. This trouble is got rid of by lengthening the arm which holds the cover; the post is then out of the way.

The second trouble affects me probably more than other microscopists. If my cover-glass gets broken or uncemented from the ring, what is to be done? I have no means of cutting a new one, and no cement by which to fix it. The only thing is to post it to town to have it repaired! Those who mount slides have cover-glasses, cements, balsam, spirit-lamps, etc., always at hand, and are unable to appreciate the difficulty such a simple case as this presents. They say, "Why not get a bottle of cement and a few covers, and then you can repair your compressor?" This is very true; but as there is no occasion to use either the cement or the cover-glasses more than once in several years, they get lost or the cement dries up, so when wanted it either cannot be found or it is not in a suitable condition for use. I therefore asked Mr. Curties to fit me a very thin plate under the lengthened arm, and spring it so as to hold a cover-glass in position.

If much pressure is wanted, a thick cover-glass can be at once slipped in, or, if an oil-immersion is to be used, a thin one can take its place. So now I am able to get along without anxiety either about scratching the front of my objective or as to where a bottle of cement may be found.

[Referring to the "improved" form of compressorium for pond-life devised by Mr. E. M. Nelson, and exhibited to the meeting, after examination of the "improvements" I desire to observe that Mr. Nelson's method of fixing the cover-glass by a thin metal spring-flange extending all round the semicircular brass ring, in order to save the small trouble of fixing the cover with a little gold-size or other cement, has the great objection that water will find its way under the flange nearly every time it is used, and it being impossible to wipe it off without removing the flange (by unscrewing two very small screws), the water will evaporate, leaving a crust or sediment behind, which in a short time will clog the flange and spoil the "improvement"! Then, whenever an oil-immersion objective is used, the oil will be certain to flow under the flange and create a much greater mess, and in the end creep over the under surface of the cover-glass and spoil the object under examination. Further objections are (1) that the cover-glass will be held less firmly than with my method; (2) that the lengthened arm carrying the cover-glass will much reduce the rigidity of the arm, which already is none too rigid in the shorter original form. The trouble of racking up the tube to turn the double nose-piece is really very slight, and is outweighed by the defects introduced.

In view of all these objections I must continue to recommend the original form of my compressor, without "improvements," with the addition possibly of a very small bottle of gold-size for fixing the cover-glass, in tightly closed bottle, which will remain good and fluid for a number of years, for those living at a distance from town and out of reach of shops.—C. F. Rousselet.]

AN IMPROVED CHROMATIC CONDENSER.

By E. M. Nelson, F.R.M.S.

(*Read March 26th*, 1912.)

Every one who has used an Abbe condenser (invented 1874) must be aware of its spherical aberration, for its aplanatic aperture is so small that it will only fill the back lens of an objective that has a very low N.A. The difference in the focus of its central rays and those used for dark-ground illumination is so great that they cannot be both used at the same time. In fact, the spherical aberration in its outer zones is sufficiently large to hinder its action as a dark-ground illuminator, for if rays about N.A. 1·0 are in focus those about N.A. 1·2 are out of focus.

The Abbe condenser owes its popularity first to its cheapness, and secondly to the advertisement it receives from those who, not knowing how to use the microscope and its lenses properly, invariably employ their highest powers in a degraded manner to examine low-power objects.

It would seem that with a little trouble something might be done to improve it, for it is obvious that one fault about this condenser is that it attempts too much; if it were cut in two, so to speak, it would perform better. In brief, would it not be advisable to have a simple form of non-achromatic dark-ground illuminator that would be capable of doing real serviceable work, and also for ordinary work a cheap narrow-angled chromatic condenser with its spherical aberration at a minimum?

The first part has been done, and the dark-ground illuminator was exhibited to you a little while ago. Those who have used it say that it gives very satisfactory results. It is a three-lens dark-ground condenser of minimum aberration; it is a possible and inexpensive construction, because it is not hampered with a central part. Now Mr. Curties will show you the central part unhampered with an oil-immersion margin. This is also a non-achromatic triplet of 0·65 N.A., and of minimum aberration.

A chromatic condenser of wide angle invented by the Rev. W. Kingsley in 1850 was made by Ross (figured in QUEKETT, "On the Microscope," 2nd ed., p. 500, 1852). This was not intended to supplant the superior achromatic condenser, but was designed to be used excentrically for obtaining blue light for resolving striae on diatoms. The blue light, formed by the chromatic dispersion of the lens, resembled that from an achromatic condenser illuminated by spectrum blue light. By this means the pearly light, formerly so much sought after by striae resolvers, was obtained.

The formula upon which this condenser is constructed, two menisci and a bi-convex, differs from that of Kingsley's, which has two bi-convex lenses and a meniscus. Its aperture, instead of being made as large as possible, is kept to 83°, so that it may be used with three quarter cone ordinary dry objectives; its aberrations are at a minimum, and it is made of low-dispersive Jena glass. These two illuminators therefore together form an improved Abbe condenser.

AN APLANATIC SPOT LENS.

By E. M. NELSON, F.R.M.S.

(*Read March 26th*, 1912.)

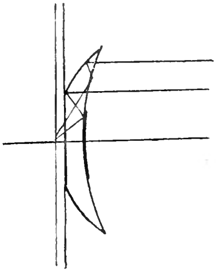
MR. STEPHENSON invented, in 1879, an immersion dark-ground illuminator, which consisted of a plano-convex lens mirror; it is figured in *Journ. R.M.S.* vol. 2 (1879), p. 36. In the description it is stated, first, that "if used with a dry lens of the highest power on a balsam-mounted object the light, unable to pass the upper surface of the covering-glass, is thrown back on the object, giving opaque illumination," and secondly that "the spherical aberration is inconsiderable."

Obviously the object must be placed slightly within the focus of the condenser, and an annular ring of light projected upon the inside of the cover-glass, there to be totally reflected back again to a focal point on the top of the object.

As no provision is made by Mr. Stephenson to correct the spherical aberration which arises at the concave surface of the mirror, the amount can hardly be inconsiderable; on the contrary, it is large enough to cause the marginal rays to focus underneath the slip.

It occurred to me that, working somewhat in the manner I have described in a previous paper, the spherical aberration might be reduced and brought within reasonable limits. This has been done, and the illuminator that Messrs. Baker will exhibit to-night will be seen to be particularly free from aberration.

This condenser focuses parallel rays directly upon the object; its N.A. is 1·3 and its focus 8 mm. A glance at the figure will show that a convex reflecting surface—which is also a concave refracting surface—has been introduced to neutralise the aberration of the concave mirror.



The optics of the device are rather interesting, for it appears that no spherical curve will give absolute aplanatism. What the precise curve necessary to do this is I am unable to tell you, for the mathematical analysis to determine that question is beyond that which I have read; but it would seem to be some sort of roller.

The residual aberration in this lens is so small that it may correctly be called "aplanatic," for it is too small to make any practical difference. As it is a single lens with spherical surfaces, it is a very simple form of a dark-ground illuminator.

ON THE "PSEUDOPODIA" (DIATOMS).

By E. M. Nelson, F.R.M.S.

(*Read May 28th*, 1912.)

A slide of Mr. Siddall's diatoms, having the so-called pseudopodia, was kindly lent to me by Mr. Angus. When the pseudopodia were examined under a Leitz apochromatic 1/12th, structure could be plainly seen inside the filaments. In one from a Coscinodiscus there was something remarkably like a spiral filament in a tube. It is, of course, well known that in certain positions minute dots appear like a spiral, and vice versa; but on one occasion, when a good straight piece was well seen, any experienced microscopist would have said that it was a spiral structure. On two filaments coming from a Biddulphia the structure was quite different, for it resembled a minutely jointed antenna.

Fig. 1.—Filament from Coscinodiscus.

Fig. 2.—Filament from Biddulphia.

The first notice of these, so far as I know, is by W. W. Wood, *Monthly Microsc. Journ.* vol. 14 (1875), p. 255, fig. unnumbered.

The next is by J. Badcock, *Journ. R.M.S.* vol. 4, ser. 2 (1884), p. 352, figs. 49 and 50, on *Surirella bifrons*. The next is by J. G. Grenfell, *Journ. R.M.S.* (1893), p. 806, and (1894) p. 415. These are very important. And finally by Lewis Wright in his handbook to the microscope, p. 233 footnote (1895).

As Mr. Grenfell's views did not agree with those of Mr. Bennett, the botanist-abstractor of the R.M.S., his papers were never published; a brief note is given of them in the Proceedings. I saw Mr. Grenfell's exhibits both at the R.M.S. meeting and subsequently in my own study. These references are of importance because Mr. T. Comber's remarks are given, and he was the greatest authority on the Diatomaceae either here or anywhere else. Mr. Grenfell's pseudopodia were like Mr. Wood's, whereas Mr. Siddall's are more like Mr. Badcock's.

RHABDONEMA MINUTUM.

By N. A. Brown, A.L.S.

(*Exhibited May 14th*, 1912.)

This slide of a marine diatom collected at Douglas, Isle of Man, and originally preserved in sea-water and formalin, demonstrates that it is possible to mount this and probably other diatoms in styrax in such a manner that the form of the chromatophores is preserved. To get rid of the salt and formalin the material was well washed in distilled water, then transferred to a cover-glass, and the water allowed to evaporate slowly from the outside of the diatom, but not from the interior. At the critical moment, when it was judged that this had been accomplished, a drop of styrax was placed on the diatom, and the mount made.

The water has dried from some of the frustules, and into these styrax has penetrated. The result is rather remarkable, for in those frustules containing water not only are the chromatophores fairly well preserved, but the structural markings of the diatom, owing to the different refractive index of the water, are seen far more clearly than on those into which styrax has penetrated, and in which the chromatophores are utterly spoilt.

It remains to be proved if this method of preserving the chromatophores is a permanent one or not. The slide, when exhibited, had been mounted about four months, and up to the time of publishing this note I have not observed any change in the frustules that contained water when first mounted.

NOTICES OF BOOKS.

An Introduction to the Study of the Protozoa with Special Reference to the Parasitic Forms. By Prof. E. A. Minchin, M.A., Ph.D , F.R.S. 8½ × 5½ in. ; xii + 520 pages, with 114 illustrations in the text. London, 1912. Edward Arnold. Price 21*s.* net.

Many members of our Club recollect with pleasure listening to the addresses delivered by Prof. Minchin during the time he was President, and can recall the clear exposition of the difficult problems relating to the Protozoa, more especially those concerning the parasitic habit exhibited by some of the forms. Readers of the *Introduction to the Study of the Protozoa* will find the same clear exposition and presentation of detail, and will feel themselves under a debt of gratitude to the author for this careful résumé of recent research in the science of Protozoology, as it is now generally called. During the last twenty years it has been demonstrated that Protozoa of parasitic habit are the cause of many diseases in man and animals, and the study has become one of very great practical importance. This has largely increased the number of workers, and at the same time a vast literature has gathered round the subject. So vast, indeed, that the time had certainly arrived when such a careful survey as we have here should be supplied.

The author's aim is to furnish a guide to those who, having a general knowledge of biology, desire a closer acquaintance with the special problems relating to the Protozoa ; to define the position of these organisms in Nature, and to determine as far as possible what should be included under the term Protozoa ; to guide the student through the maze of technicalities surrounding the subject, and to present a systematic classification of the vast series of forms, based on their mutual affinities and inter-relationships. The microscopist who has specialised in any section of the Protozoa, such as the Rhizopoda or Foraminifera, will find much to interest him in the earlier chapters, dealing as they do with the Organisation of the Protozoa and their Reproduction. The chapter following these treats of the question of sex and the sexual process, and as any theory relating to the origin of sex in the higher animals and plants must be founded on a knowledge of the origin and signification of the syngamic process in the Protista—*i.e.* organisms belonging to what has been styled by the author the "cellular grade"—the importance of this section is readily seen.

Any attempt at a "natural" classification of the Protozoa must be fraught with many difficulties, for before deciding on the affinities of any organism it is necessary to know its life-history, and in many cases that is unknown, or but imperfectly known. In the Systematic Review of the Protozoa the author adopts the four old-established divisions or classes: Sarcodina, Mastigophora, Sporozoa and Infusoria. The affinities of the parasitic forms are discussed, and these are of very great interest from a biological point of view. In the Metazoa parasitism seems to simplify the life-cycle, while in the Haemoflagellates, or blood-parasites, and in the intra-corpuscular Haemosporidia, of which the malarial parasite is an example, the life-cycle has increased in complexity, especially as regards sexual reproduction. This has probably arisen as a result of the life-cycle being partly spent in an intermediate invertebrate host. The opinion that the Haemoflagellates have arisen along two distinct lines of ancestry is accepted, but accepted with a caution.

The majority of the figures have been specially drawn from the original sources or from actual preparations, and the artists are to be congratulated on their share in the work.

The bibliography is grouped under the chapter headings, and includes over eight hundred titles; this, with an index, completes a work for which the author deserves the highest praise.

THE CLUB CABINET.

The following Slides have recently been added to the Cabinets :

Rhizopoda.

Presented by Dr. E. Penard.

K.A. 52. *Amoeba alba.*
53. *Amoeba fibrillosa.*
54. *Amoeba laureata.*
55. *Amoeba sphaeronucleosa.*
56. *Amoeba terricola.*
57. *Amphitrema flavum.*
58. *Arcella arenaria.*
59. *Arcella catinus.*
60. *Arcella dentata.*
61. *Arcella vulgaris.*
62. *Amerinzewia cylostoma.*
63. *Bullinula indica.*
64. *Centropyxis aculeata.*
65. *Centropyxis horrida.*
67. *Corycia flava* (Geneva).
68. *Corycia flava* (Colombia).
66. *Cyphoderia myosurus.*
69. *Difflugia bacillifera.*
70. *Difflugia bicuspidata.*
71. *Difflugia bidens.*
72. *Difflugia gramen.*
73. *Difflugia hydrostatica.*
74. *Difflugia molesta.*
75. *Difflugia subaequalis.*
76. *Diplochlamys gruberi.*
77. *Euglypha armata.*
78. *Euglypha branchiata.*
79. *Euglypha compressa.*
80. *Euglypha ciliata.*
81. *Euglypha scutigera.*
82. *Heleopera rosea.*
83. *Nebela ansata.*

K.A. 84. *Nebela flabellulum.*
85. *Nebela gracilis.*
86. *Nebela griseola.*
87. *Nebela lageniformis*
88. *Nebela longicollis.*
89. *Nebela militaris.*
90. *Nebela minor.*
91. *Nebela parvula.*
92. *Nebela tincta.*
93. *Nebela vas.*
94. *Pamphagus granulatus.*
95. *Pelomyxa palustris.*
96. *Phryganella nidulis.*
97. *Plagiopyxis callida.*
98. *Pontigulasia vas.*
99. *Pyridicula cymbalum.*
100. *Quadrula symmetrica.*
101. *Trinema enchelys.*

Rotifera.

Presented by D. Stevens.

Rot. 243. *Proales* (*Notommata*) *gigantea* (adult).
244. *Proales* (*Notommata*) *gigantea* (various stages)
245. *Proales* (*Notommata*) *gigantea* (two snails' eggs: one infected and the other clean.

Hydrozoa.

Presented by C. J. H. Sidwell.

M.A. 49. *Cordylophora lacustris.*

Polyzoa.

Presented by C. J. H. Sidwell.

M.B. 83. *Plumatella repens.*

Entomological.

Purchased.

R. 216. Scales of Podura.
388. Alimentary canal of Blow Fly ♂.
389. Alimentary canal of Blow Fly ♀.

T. 88. Head of Silkworm Moth ♂.
S. 42. *Anagrus* sp. Fairy Fly (F. Enoch).

Marine Algae.

Presented by C. J. H. Sidwell.

B. 110. *Castagnea virescens.*

Diatomaceae.

Presented by H. Morland.

A. 173. *Kittonia elaborata.*

Rock Sections.

Purchased.

Y.B.	124.	Andesite, Porphyritic	Blackford Hill, Edinburgh.
	125.	Andesite, „	Whinney Hill.
	126.	Andesite, Hypersthene	Dumyat, Stirling.
	127.	Aplite	Meldon, Devon.
	128.	Aplite-Quartz-Felspar, with little Mica	Jersey.
	129.	Augitic-Teschenite	Inchcolm, N.B.
	130.	Basalt	Hills Quarry, Moira, Ireland.
	131.	Basalt	Blue Hills, Greenland.
	132.	Basalt Dolerite	Tynemouth Dyke, Northumberland.
	133.	Basalt-Mellilite	Speigel Rv. Valley, C. Colony.
	134.	Basalt, amygdaloidal	Giant's Causeway, Ireland.
	139.	Diorite, orbicular on Napoleonite	Corsica.
	110.	Dunite	Mount Dun, N. Z.
	105.	Eurite Vein	Third Rock, Co. Dublin.
	106.	Eurite Reibeckite	Ailsa Craig, N.B.
	113.	Felsite, spherulitic, with small spherulites	Wellington, Salop.
	114.	Felsite	Lea Rock, Wellington, Salop.
	101.	Gabbro	Loch Cornish, Skye.
	102.	Gabbro-Olivine	Skye.
	119.	Gneiss-Cordierite	Bodenmais, Bavaria.

Y.B.	55.	Granite	Assouan, Egypt.
	89.	Granite, Cheesewring	Cornwall.
	86.	Granite, Dartmoor	Barrymore Bdg., Devon.
	85.	Granite	Mount Sorrel, Leicester.
	90.	Granite, Leinster	Third Rock, Co. Dublin.
	91.	Granite, Dufton Micro-	Appleby, Westmorland.
	87.	Granite, Shap	Wastdale Crag, Westmorland.
	100.	Granite, Shap, basic secretion	Wastdale Crag, Westmorland.
	88.	Granite, Tourmaline	Luxulian, Cornwall.
	108.	Grit, Coarse Blue	Stoke-on-Trent.
	118.	Hälleflinta	Dannemoura, Sweden.
	115.	Horneblende, Picrite	Anglesea, Wales.
	116.	Horneblende, Schist	The Lizard, Cornwall.
	129.	Horneblende, Tesch	Inchcolm, N.B.
	77.	Kersantite	Brittany.
	138.	Leucite, Lava	Vesuvius, 1819.
	123.	Limestone, Endothyra	Leek, Staffs.
	80.	Minette	Swindale Beck, Westld.
	117.	Mica-Schist	Route de Simplon, Italy.
	112.	Norite	Maud Junc., Aberdeen.
	135.	Obsidian	Tulanango, Mexico.
	111.	Peridotite	Sutherland, N.B.
	107.	Phyllade, with Ottrelite	Pyrenees.
	136.	Pitchstone	George Town, Colorado.
	137.	Pitchstone	Glen Laiulash, Arran.
	95.	Quartz, Augite-Syenite	Enderby.
	98.	Quartz, Dolerite	Inchcolm, N.B.
	97.	Quartz, Enstatite-Diorite	Penmaenmawr, N. Wales.
	96.	Quartz, Felsite (spherulitic)	St. John's, Westmorland.
	99.	Quartz, Red-Porphyry	Carn Brea, Cornwall.
	109.	Rhyolite, Fluidal	Ballymena, Ireland.
	122.	Sandstone, Glauconite	Malvern.
	120.	Slate, Ottrelite	Ottré, Belgium.
	121.	Slate, Sillimanite	Bodenmais, Bavaria.
	92.	Syenite	Buttermere, Lake Dist.
	93.	Syenite	Croft Quarry, Leicester.

Y.B. 94.	Syenite	Markfield, Leicester.
103.	Trachyte	Nth. Berwick Law.
104.	Trap Tuff	Arthur's Seat, Edinburgh.

Exchanged.

Y.B. 140.	Augite-Andesite	Cleveland Dyke, Yorks.
148.	Augite Granite	Mull, N.B.
141.	Basalt	Faroe Islands.
142.	Basalt: Markle type	Lairs Low, N.B.
143.	Basalt, with tachylite edges	Castle Craigs, N.B.
144.	Basalt, vesicular	Cape Royds, Antarctic.
145.	Chiastolite Slate	Rhine.
146.	Dolerite: Dunsaple type	King's Pk., Edinburgh.
147.	Gabbro	Cunsfell, Cumberland.
149.	Granite-Porphyry	Dufton Pike, Westmorland.
150.	Granite-Porphyry	Trevor Quarry, Carnarvon.
163.	Granite-Porphyry	Threlkeld, Cumberland.
151.	Glaucophane-epidote-schist	Llanfair P. G., Anglesea.
152.	Gneissic-Hypersthene-Gabbro	Bellinzona Soizzero, Italy.
148.	Granophyre	Mull, N.B.
153.	Hornblende-Andesite	Bolvershahn, Germany.
154.	Hornblende-Dolerite	Mancetter, Warwick.
155.	Hornblende, Quartz-Porphyrite	Quenast, Belgium.
156.	Kersantite	Willischthal.
157.	Kenyte, with vitreous base	Cape Royds, Antarctic.
158.	Limestone, metamorphosed	Iona, N.B.
159.	Mica-Schist	Roseg Thal, Switzerland.
160.	Mica-Schist with Pegmatite	Cape Royds, Antarctic.
162.	Mica (Muscovite): Biaxial interference figure.	
161.	Minette	Swindale Beck, Westmorland.

Y.B. 164.	Nepheline Basanite	Butterton Hall Pk., Staffs.
165.	Olivine Basalt	Linz a. Rh., Germany.
166.	Ophitic Dolerite	Saltcoats, N.B.
167.	Ophitic Diabase	Moel y Gest, Carnarvon,
168.	Paisanite (Biebeckite-Eurite)	Ailsa Craig, N.B.
169.	Porphyrite	Narborough, Leicester.
170.	Quartz: Uniaxial interference figure.	
171.	Quartz-Augite-Diorite	Ben Cruachan, N.B.
172.	Quartz-Mica-Gabbro	Carrock Fell, Cumberland.
173.	Quartz-Porphyrite	Lessines, Belgium.
174.	Quartz-Porphyry	Mynydd Mawr, Carnarvon.
175.	Slate (Metamorphosed Skiddaw, with Chiastolite)	Quarry, Glasgow.
176.	Teschenite	Quarry, Glasgow.
177.	Teschenite	Quarry, Glasgow.
178.	Theralite	Saltcoats, N.B.
179.	Volcanic Tuff	Bardon Hill, Leicester.

PROCEEDINGS

OF THE

QUEKETT MICROSCOPICAL CLUB.

At the meeting of the Club held on March 26th, 1912, Prof. Arthur Dendy, D.Sc., F.R.S., President, in the chair, the minutes of the preceding meeting, held on February 27th, were read and confirmed.

Messrs. B. W. Tibble and John Metcalfe were balloted for and duly elected members of the Club.

The list of donations to the Club was read and the thanks of the members voted to the donors.

The following papers by Mr. E. M. Nelson, F.R.M.S., were read by the Honorary Secretary (Mr. W. B. Stokes): "An Aplanatic Spot Lens," "An Improved Chromatic Condenser," "A Suggested Improvement to the Rousselet Compressor."

Mr. C. L. Curties exhibited an aplanatic spot lens designed by Mr. E. M. Nelson as an improvement upon one shown by Mr. Stephenson in 1879. It had a Numerical Aperture of 1·3, and was practically free from spherical aberration.

A very important paper on "The Lagenae of the South-West Pacific," by Mr. Henry Sidebottom, was read by Mr. A. Earland, F.R.M.S., who said the Club was to be congratulated on having obtained so valuable and beautifully illustrated a contribution to the Journal. The collection of specimens discussed was made by the late Mr. W. Blundell Thornhill, of Castle Bellingham, Ireland, who, in correspondence with Mr. Earland, at first proposed some 200 new species. All forms of Lagena are variations of one original type resembling a soap-bubble with one aperture, as in *L. globosa.* The group has been a puzzle to rhizopodists for the last fifty years at least, and various attempts at classification have been made. Those by Williamson, Reuss, Parker and Jones, and Brady were mentioned. Mr. Sidebottom has adopted, with modifications, Brady's system.

The President said the paper brings again to our notice the fact that "species" are but human inventions after all, and, as Lamarck long ago told us, Nature does not recognise them. One noticed many points of apparent complete uselessness, as, for instance, the elaborate exterior ornamentation of many of the tests of these tiny organisms. What could it possibly matter to an amoeboid organism whether it had one or other microscopic pattern on the exterior of its shell?

Mr. C. F. Rousselet, F.R.M.S., read a paper on "Some Rotifers." These were *Notholca triarthroides* Skorikow; *Cathypna brachydactyla* Stenroos; and a new species, *Brachionus spatiosus*, from Devil's Lake, North Dakota, U.S.A. He was strongly of opinion that every description of a new Rotifer should be accompanied by a good figure, because a drawing is always remembered, whilst a description without a figure is usually lost sight of and forgotten. Mounted specimens of the species described were exhibited under microscopes.

Mr. D. Bryce read a paper "On Three New Species of Callidina." These were *Callidina nana*, *C. concinna* and *C. decora*. He took the opportunity of recommending attention to the form of the "upper lip" as one of the most valuable characters which go to make up the individuality of species of the Philodinidae. The earliest mention found of this structure is by Milne, who, early in 1886, referred to it as the "brow." Later in the same year Zelinka named it the Upper Lip ("Oberlippe"), and made use of it in his descriptions of two new species. The upper lip is not possessed by all the Bdelloida, but only by those which constitute the family Philodinidae. It is not actually a part of the corona, and is only visible when the wheel-organ is displayed, and is withdrawn with it within the mouth when the animal resumes its normal or creeping position. It is convenient to look upon it as a subsidiary part of the corona, of which, in many cases, it has become the dominant characteristic (from the point of view of the student). When the ciliated discs on their pedicels have been pushed forth from the widely opened mouth, the upper lip becomes visible in direct dorsal view as an unciliated surface of the head in front of the reserted rostrum, merging gradually at either side into the "collar," the wider part immediately succeeding the lateral bases of the pedicels. Mr. Bryce illustrated his descriptions by blackboard diagrams of the structures concerned.

Mr. A. E. Conrady, F.R.A.S., spoke on the resolving power obtainable with dark-ground illumination. He thought the matter would be of interest, as this method of illumination was so usual now in examining, say, living bacteria with high powers. This method has been styled ultra-microscopic, but this is an implied contradiction; all that dark-ground illumination does is to render visible by contrast in illumination—that is, very translucent objects are rendered visible, and sometimes strongly visible, by dark-ground illumination. His remarks were based on the Abbe theory as applied to gratings, as the only other theory—Airy's spurious-disc theory—had never been carried beyond Airy's determination of the form of a star-image. Mr. Conrady demonstrated that the *full* resolving power of an objective was only obtainable when the dark-ground illuminator had three times the numerical aperture of the objective, that otherwise the resolving power was equal to one-fourth that of the objective plus one-fourth that of the condenser. No higher resolving power can be obtained with dark-ground illumination than will be given with an objective having a numerical aperture of 0·47. (In practice, 0·6 was found to be the limit.) Particular stress was laid on the necessity for the dark-ground stop to be but little in excess of the absolutely necessary size.

Mr. W. B. Stokes (Hon. Sec.) said that Mr. Conrady had not given them any practical results, an omission which he himself was fortunately able to fill. It seemed to him that Mr. Conrady's assumptions were not such as were generally accepted. Dark-ground illumination was used to display objects which were thought to *refract* light fairly strongly, and it was mainly by the light refracted by the details of the object that the image was formed. Silicious fibrils, as in diatoms, bacteria, scratches (rulings) on glass, etc., deflected the course of the light which passed through them, and it would be difficult to predict the position of spectra formed by this light. The object appears as if self-luminous, even in the case of rulings on glass, when the individual lines shine and the clear interspaces are dark. Mr. Conrady's assumption was that the light was not refracted, and his ideal object would probably be a grating with opaque bars and clear interspaces, an object which, on dark ground, would give a very disappointing image. It would not be surprising, therefore, if Mr. Conrady's theoretical results did not agree in practice. Mr. Stokes added that, finding his own experiments did not agree with the spectrum theory, he had asked Mr. Nelson to investigate, and had received from him a number of results, some of which were quoted, which gave a practical resolving limit of nearly 80,000 lines to the inch, multiplied by the numerical aperture of the objective, results which were far higher than those predicted for medium and high apertures by Mr. Conrady. These resolutions were not blue ones, but white, and many of them had been checked by himself. He thought, therefore, that they would be justified in rejecting this particular application of the Abbe theory to dark-ground images.

Mr. Conrady, replying, pointed out that refraction, etc., by the object was not an alternative to, but was included in, the Abbe theory, as the scientific treatment of optics dealt with wave-motions only, and made no distinction between refraction, reflection and diffraction, which were peculiar to the narrow treatment in elementary textbooks. The experiments described by his critic were far too crude to either confirm or disprove his (Mr. Conrady's) results, as white light had been used, and on miscellaneous objects. It must be remembered that white light included wave-lengths—and resolving powers—of from three-quarters up to one and a half times that usually adopted as an average (that is, light of wave-length 5,500 A.U.).

Mr. A. A. C. Eliot Merlin, F.R.M.S., sent a "Note on a Photograph of the Secondary Structure of *Navicula Smithii*." This had reference to some observations communicated to the Club, October 18th, 1907, and, the writer said, left no room for reasonable doubt of the objective reality of the structure described. The photograph was obtained at a direct magnification of 2,900 diameters, with an apochromat $\frac{1}{8}$ in. of 1·42 N.A., and an axial illuminating cone of 0·5 N.A. This exceedingly undesirable procedure was rendered necessary in consequence of the exterior surface of the valve being markedly convex, so that with a large cone it was found practically impossible to focus accurately at the same time more than one or two of the primaries on the camera screen.

Mr. A. Morley Jones said that he had recently mentioned to Dr. Butcher, of Blackpool, that this paper by Mr. Merlin was to be read, as he thought that as Dr. Butcher had been studying this diatom for some years he might like to send a few photographs for comparison with Mr. Merlin's. In reply Dr. Butcher sent some notes on the subject (then read), and a series of ten high-power photographs, taken at consecutive foci from the white-dot down to the black-dot image, which were much admired.

At the meeting of the Club held on April 23rd, 1912, Prof. E. A. Minchin, M.A., F.R.S., Vice-President, in the chair, the minutes of the preceding meeting, held on March 26th, were read and confirmed.

Messrs. Arthur Mead, William Henry Owen and Reginald Ernest Raab were balloted for and duly elected members of the Club.

The list of donations to the Club was read, and the thanks of the members voted to the donors.

Mr. C. Lees Curties, F.R.M.S., for Messrs. Baker, exhibited a new 1½-in. objective of N.A. 0·18, just placed on the market by his firm. The image of the test-object, proboscis of blowfly, was exceedingly good, both for definition and absence of colour-fringes. An example of the simple apertometer devised by Mr. Cheshire was also exhibited.

Mr. A. W. Stokes exhibited and described several models and methods of applying electric lighting to the microscope. He said that, usually, the lamp was separate from the microscope stand, so that the slightest movement of either was apt to upset or at least disturb the illumination. He had several contrivances to show which he had found useful. One method was to have a lamp fixed to the body of the stand by a brass arm. The lamp was hidden from the eye by a light metal tube. Once the light was adjusted on the object it remained so. Current could be taken from an ordinary lamp-pendant or wall-plug. If no company's supply was available recourse could be made to the very convenient small pocket battery, which could be fixed to its adjustable arm. Such a battery gave four hours' light, at a cost of fourpence, and it was then quite easy to replace with a new cell. In another form the microscope was fixed on a wooden base with a pocket-battery supplied with a switch. This was adjusted as required, and the whole stand could be carried or moved about without altering the illumination.

A short paper on *Proales* (*Notommata*) *gigantea* Glascott, by Mr. John Stevens, F.R.M.S., was read by Mr. C. F. Rousselet.

Mr. Stevens had sent three mounts for the Club's cabinet, and one of these, exhibited by Mr. Rousselet, showed very clearly the principal points described.

Mr. Rousselet said that at the last meeting of the Royal Microscopical Society Mr. Siddall, of Chester, exhibited some living diatoms which he said had radiate pseudopodia. He had some of Mr. Siddall's material, and exhibited, under dark-ground illumination, some of the specimens referred to.

Mr. D. J. Scourfield thought the processes were not protoplasmic, but possibly siliceous. After two days' watching he had found they occupied precisely the same position all the time. They were not affected by nitric acid or alcohol. In appearance they certainly resembled the radiate pseudopodia of Heliozoa.

Prof. Minchin said that it was quite a revolutionary idea to record diatoms with pseudopodia; but, especially after what Mr. Scourfield had said, he thought it hardly likely that they were really pseudopodia. If they were it should be possible to observe, with high power, the usual streaming movements. But even if these processes were pseudopodia they would not account for the movements of diatoms.

Dr. Duncan J. Reid read a paper dealing with "Critical Illumination in Visual Work with the Microscope."

The subject was treated under the following heads: (1) The Most Suitable Light; (2) Collecting Lenses; (3) The Principles of Correct Illumination: (A) As regards the Field, (B) Filling of the Objective with Light; (4) Condensers; (5) Distance of Lamp from Substage Mirror; (6) Critical and Non-critical Illumination; (7) Working Aperture; (8) General Arrangement of Light and Apparatus in High, Medium and Low-power Work.

Dr. Spitta said he congratulated Dr. Reid upon the neat way in which he had placed the subject before them, and had nothing to add to what had already been said. He quite agreed that illumination with low powers was difficult, but whereas Dr. Reid recommended oil lamps, he could only say that he abhorred them, the electric light or limelight requiring so much shorter exposure in photographing objects.

Mr. Stokes said as regarded the use of the bull's-eye he did not think that it was at all necessary, as it never improved anything, and although it gave a larger field of light personally he thought the bull's-eye was a mistake. For high powers a lamp was good enough for him, and for a large bright field the flat of the flame would give all that was required. The ordinary bull's-eye had far too long a focus for use with large substage condensers.

Mr. F. Orfeur said the next best thing as an illuminant was the oxy-hydrogen light—but he had lately adopted an inverted gas burner with success, having made an opaque chimney of a piece of brass tube with a ¾-in. hole drilled in it.

Mr. M. Blood had spent a great deal of time in experimenting as to the best illumination to be obtained, and found that the best was obtained by using the edge of the flame, which gave quite a nice resolution—but by using a particularly well corrected condenser he found the resolution was very much improved under an apochromat of 1·4 mm. With a bull's-eye they could not have critical illumination, and this might possibly explain why Dr. Reid could find so little difference between the photographs he had shown them.

Dr. Reid having replied, Prof. Minchin said they had listened with great interest to this paper and had very heartily to thank Dr. Reid for it.

The thanks of the meeting were unanimously voted to Dr. Reid accordingly.

Mr. C. D. Soar, F R.M.S., exhibited twenty-one sheets of beautifully coloured figures of water-mites. He said they illustrated all the recorded species of the genus Arrhenurus found in the British Isles. This genus is the most interesting of all the genera of the Hydrachnidae, and contains over 200 species from different parts of the world. It has the largest variety of forms. The males are quite distinct in shape from the females, and the last and not least interesting feature is the beautiful and brilliant colouring which they exhibit. Fifty species have been recorded in Britain.

Mr. F. Enock, F.L.S., etc., was proposed as an Honorary Member of the Club, on behalf of the Committee.

At the meeting of the Club held on May 28th, Mr. E. J. Spitta, L.R.C.P., M.R.C.S., Vice-President, in the chair, the minutes of the preceding meeting, held on April 23rd, were read and confirmed.

Messrs. T. R. Brooke, A. E. Bull, R. Weiss, E. J. Barnard, T. F. Barrett and K. F. Barrett were balloted for and duly elected members of the Club. Mr. F. Enock, F.L.S., was duly elected an Honorary Member of the Club.

The list of donations to the Club was read and the thanks of the members voted to the donors.

The Chairman said that they had present as a visitor Dr. J. C. Kaufmann, secretary and founder of the Melbourne (Vic.) Microscopical Society, and he asked members to express their pleasure at seeing him, and to extend their usual hearty welcome to visitors, and especially to one who had come so far.

Dr. Kaufmann said he much appreciated the hearty welcome accorded him. They had at the Antipodes a good many hard workers, especially, perhaps, in Melbourne. The society which he started some four years ago had now about 200 members, including many men of note in that part of the world. They had many pond-workers—perhaps a majority. Mr. J. Shephard, of Melbourne, a member of the Quekett Club, was also an enthusiastic worker on parasites. They had many medical men on their roll, and the number of microscopical workers in Victoria, New South Wales and South Australia was steadily increasing.

The Chairman drew attention to the fine series of preparations mounted and exhibited by Messrs. Clarke and Page under microscopes provided by Messrs. Watson & Sons.

The Hon. Sec. read a short note by Mr. E. M. Nelson, F.R.M.S. The writer said that Mr. Angus had lent him a slide of Mr. Siddall's diatoms having the so-called pseudopodia. When the "pseudopodia" were examined under a Leitz 1/12 oil apochromat, structure could be plainly seen inside the filaments. In one form, a Coscinodiscus, there was something remarkably like a spiral filament in a tube. It is, of course, well known that in certain positions minute dots appear like a spiral; but on one occasion, when a good straight piece was well seen, any experienced microscopist would have said that it was a spiral structure. On two filaments coming from a Biddulphia the structure was quite different, for it resembled a minutely jointed antenna. (Two drawings were exhibited in illustration.)

Mr. A. Earland thought this was a very valuable report, as, if markings are present, the filaments cannot be pseudopodia.

He thought the evidence at present was in favour of their being parasitic or bacterial growths, as suggested by Mr. N. E. Brown.

Mr. D. Bryce said a similar appearance had been observed parasitic on certain Philodina.

Mr. J. Milton Offord said he took the filaments to be either silicious or similar to setae.

Mr. W. B. Stokes (Hon. Secretary) opposed the parasitic theory, and reminded the meeting that Mr. Scourfield had shown these filaments to be stiff and resistant to strong reagents. The probability was in favour of their being silicious processes belonging to the diatom. Students of diatom structure had ceased to be surprised at the vagaries of this resourceful group.

The Chairman said there was considerable diversity of opinion as to the true nature of the observed structures. He thought that Mr. Siddall had, perhaps, used the term "pseudopodia" with a different meaning to that usually understood. The usual meaning was, of course, connected with amoeboid movement, and where the structures appeared and disappeared while under observation. It may be that they are excrescences, or they may be parasitic in nature, or not necessarily protoplasmic at all. Mr. Siddall had said that he saw the pseudopodia retracted into the organism. Whatever these structures may be, they have excited a considerable amount of interest.

Mr. R. T. Lewis, F.R.M.S., read "A Note on *Solpuga ferox*." In illustration of his paper, Mr. Lewis exhibited under microscopes preparations of Solpuga showing: (1) Extremity of a pedipalp; (2) extremity of first leg, showing striated hairs; (3) extremity of second leg, showing jointed claw; (4) fourth leg, showing the malleoli in position; (5) one of the malleoli more magnified; and (6) hairs from the inner surface of chelicerae. Several preserved and mounted cabinet specimens were also exhibited. The paper was further illustrated by coloured diagrams.

Mr. Conrady, F.R.A.S., describing "Some Experiments on Alternative Microscopical Theories," said that it had been claimed in the discussion on his previous communication that the light scattered by diatoms, glass-rulings, etc., was due to refraction, but he had found that all the observational facts contradicted this suggestion. Diffraction, on the other hand, not only demanded the exact appearance seen on looking down the tube, but enabled him to obtain very fair determinations of the wavelengths of red, green and violet light from the dots of *Pleurosigma formosum*, and from the divisions of a stage micrometer. As a matter of fact, Abbe had described—thirty years ago—very careful experiments made by him to prove that refraction could not explain the behaviour of microscopical objects. Refraction might, however, considerably alter the relative brightness of the diffraction-spectra, but without affecting their position.

The following objects were exhibited: Larva of *Stratiomys chamaelion*, by Mr. E. E. Banham; corneal epithelium, showing variously shaped cells, by Mr. J. T. Holder; a specimen of the beautiful diatom, Bacteriastrum sp., from the Challenger collections, by Mr. A. Morley Jones.

At the meeting of the Club held on June 25th, 1912, Prof. Arthur Dendy, D.Sc., F.R.S., President, in the chair, the minutes of the preceding meeting, held on May 28th, were read and confirmed.

Messrs. J. Gurney, W. N. Jaquin, G. F. W. Howorth, G. F. Hook and J. C. Morris were balloted for and duly elected members of the Club.

The list of donations to the Club was read and the thanks of the members voted to the donors.

The Hon. Sec. said that Mr. F. Whitteron, of Geelong, who was present as a visitor, had brought a number of specimens of a rare Holothurian, *Trochodota dunedinensis*, for distribution to members who wished to examine it.

The President said the Club was exceedingly fortunate in having such a gift. It happened that this organism had peculiar interest to him. He knew Geelong well, and had done a good deal of dredging in Port Phillip, but *T. dunedinensis* came not from Geelong, but from New Zealand, and was named after the city of Dunedin by Prof. Parker. He had collected it at Dunedin, and had written an account, with figures, which appeared in the *Zoological Journal* of the Linnean Society some twelve to fifteen years ago. It has a variety of shapes of spicules, and in particular some of a special wheel-like form. He had been fortunate enough to work out the development of these spicules, which made some of the most fascinating microscopic objects it was possible to imagine.

Mr. F. Whitteron said the specimens he had brought had been identified by a Fellow of the R.M.S., so he could speak with authority as to their specific identity. He had received them from Mr. M. J. Allan, of Geelong, who had collected them in Corio Bay.

The President said that Mr. Whitteron had also brought for distribution some Globigerina collected from rocks at Geelong. He would suggest that it was possible that the Geelong form of Trochodota might be slightly different from the New Zealand form.

The thanks of the Club were voted to Mr. Whitteron.

The Hon. Sec. read a note from Mr. E. M. Nelson on the so-called pseudopodia of diatoms. The first notice of these, so far as could be traced, is by W. W. Wood, *Monthly M. Journal*, vol. xiv. p. 255 (fig.)., 1785. Next by J. Badcock, *Journal R.M.S.*, vol. iv., ser. 2, 1884, p. 352 (fig.) on *Surirella bifrons*. Then a notice by J. G. Grenfell, *Journal R.M.S.*, 1893, p. 806, and 1894, p. 415. Mr. Nelson wrote that he saw Mr. Grenfell's exhibits both at the R.M.S. meeting, and subsequently in his own study.

The Hon. Sec. (W. B. Stokes) read a paper "On Resolutions obtained with Dark-Ground Illumination and their Relation to the 'Spectrum' Theory."

Mr. A. E. Conrady, F.R.A.S., said that in his original paper (read March 26th), on dark-ground illumination, he carefully avoided expressing any definite number of lines per inch. Any such statement brings one on to very difficult ground. Referring to the difficulty of critically testing a theory, he said that it was usually thought that a theoretical man works it out and leaves the matter so that any practical man can test it. But it is exceedingly difficult to test any theory so closely. The results given by the objective of 0·86 N.A., using light of wave-length 5,000, agree very well with the figures he (Mr. Conrady) had already given. The actual difference between Mr. Stokes's figures and his own was that between 55 and 60, while the differences between Abbe and Airy are as much as between 57,000 and 80,000 (lines per inch). It is very difficult to arrive at a definition of the limit. Can any worker be sure that he is really working under the conditions laid down by either theory? The formula which they had heard quoted for the resolving limit applied to a grating which is absolutely uniform in ruling, and, secondly, to a grating also which has an infinite number of lines —that is, practically, if 60,000 to the inch, there should be many inches so ruled. When a grating has a limited number of lines, it becomes easier to resolve. Grayson's 30 lines at 60,000 is in this way subject to a 3 per cent. discount. No grating is really uniform, and the "ghost" spectra have also been called into use to help resolution. Referring again to the Grayson rulings, Mr. Conrady said that we have only Mr. Grayson's word as to the number of lines ruled. Some time ago Mr. Merlin published in the *Journal R.M.S.* an account of a series of measurements he had made of these fine rulings. He found that the different spaces in one band varied as much as 10 per cent. But Mr. Merlin did not attempt to measure whether the 60,000 band was really 60,000. He only compared it with the 10,000 band, and we have no knowledge as to the accuracy of the 10,000 band. There is no standard of reference for such things. Dr. Spitta had recently measured some coarse rulings over one inch by Mr. Grayson. These showed a periodic error in the dividing, and, further, the inch divisions did not agree in value with a similar space divided into metric values. He believed, however, that Mr. Grayson did not claim that these rulings were absolutely correct. The coarsest line in a group will influence the resolution of that group.

Mr. Stokes said that he was quite satisfied with the undulatory theory, and also that it would be quite equal to all demands made upon it by microscopists.

After the meeting Mr. Stokes exhibited the 60,000 band of a Grayson ruling resolved with an objective of N.A. 0·835, and a dark-ground illuminator of N.A. 1·34.

Mr. R. W. H. Row, B.Sc., who was introduced by the President, said that some ten days ago some curious objects were found on a platform at Malden railway station in Surrey, and were brought to King's College. The appearance at Malden was as if the whole of the gravel of the platform was jerking about in a series of spasmodic movements. The sycamore trees overhanging the platform showed in many cases brown patches on their leaves. On being held up to the light, a little black spot was seen in the brown patch. This proved to be a larva, between the upper and under sides of the leaf, feeding on the soft mesophyll. It probably effected an entrance through a water-pore. (Specimens of leaves so attacked were exhibited.) When the larva is fully fed, it starts to cut out a circle from the leaf it is living on, but the cut is not continuous; at the same time it spins threads across the circular piece, and presently forms a complete capsule, at first soft and easily damaged, but which soon becomes quite hard. The circular cut is then completed, and the detached piece falls to the ground. The surface of the ground below the attacked trees looked as if strewn with light-brown confetti. Light and heat, even the warmth of the hand, stimulate the jumping, which appears to be due to the preference of the larva, now assuming the pupal form, for shade against direct light. (The specimens exhibited were too far advanced towards pupation to jump.) The insect, which proved to be Phyllotoma, one of the saw-flies, is quite rare, and has been only recorded for Great Britain on a few occasions. It has also been seen this year at Ealing.

The President said the appearance was quite like brown confetti hopping about, and reminded one of the Mexican jumping bean, the movement of which was probably due to a similar cause.

Mr Perks thought that they ought not to allow Mr. Row to leave without giving him their thanks for his communication—under the circumstances the President could hardly do this, he had therefore great pleasure in proposing a hearty vote of thanks to Mr. Row for his kindness in coming there that evening.

The thanks of the Club were thereupon voted to Mr. Row with acclamation.

Mr. A. Earland exhibited a new species of Foraminifera, *Psammosphaera rustica* (A. and E.) from the North Sea. It is one of the Astrorhizidae, and constructs a polyhedral chamber by selecting a few long sponge-spicules and filling up the interspaces with smaller fragments of spicules, the whole being cemented together in a single layer.

INDEX.

OFFICERS AND COMMITTEE.

(Elected February 1911.)

PRESIDENT:

PROF. E. A. MINCHIN, M.A., F.R.S.

VICE-PRESIDENTS:

THE RT. HON. SIR FORD NORTH, F.R.S., F.R.M.S.
C. F. ROUSSELET, Curator R.M.S.
D. J. SCOURFIELD, F.Z.S., F.R.M.S.
E. J. SPITTA, L.R.C.P., M.R.C.S., F.R.A.S., F.R.M.S.

COMMITTEE:

S. C. AKEHURST.
D. BRYCE.
J. BURTON.
C. H. CAFFYN.
A. EARLAND, F.R.M.S.
E. HERON-ALLEN, F.L.S., F.Z.S., F.R.M.S.
R. INWARDS, F.R.A.S.
R. PAULSON, F.R.M.S.
J. RHEINBERG, F.R.M.S.
C. D. SOAR, F.L.S., F.R.M.S.
C. TURNER.
J. WILSON, F.R.M.S.

HON. TREASURER:

F. J. PERKS, 48, *Grove Park, Denmark Hill, S.E.*

HON. SECRETARY:

W. B. STOKES, 4, *Winn Road, Burnt Ash Hill, Lee, S.E.*

HON. ASSISTANT SECRETARY:

JOHN H. PLEDGE, F.R.M.S., 23, *Canterbury Road, West Croydon.*

HON. SEC. FOR FOREIGN CORRESPONDENCE:

C. F. ROUSSELET, Curator R.M.S., *Fir Island, Mill Hill, N.W.*

HON. REPORTER:

R. T. LEWIS, F.R.M.S., 41, *The Park, Ealing, W.*

HON. LIBRARIAN:

SYDNEY CHAS. AKEHURST,
60, *Bowes Rd., Palmer's Green, N.*

HON. CURATOR:

C. J. H. SIDWELL, F.R.M.S.
46, *Ashbourne Grove, Dulwich, S.E.*

HON. ASSISTANT LIBRARIAN:

C. H. CAFFYN, 32, *Falkland Road, Hornsey, N.*

HON. EDITOR:

A. W. SHEPPARD, F.R.M.S., 1, *Vernon Chambers, W.C.*

a

PAST PRESIDENTS.

	Elected
*EDWIN LANKESTER, M.D., F.R.S.	July 1865.
*ERNEST HART	,, 1866.
*ARTHUR E. DURHAM, F.R.C.S., F.L.S.	,, 1867-8.
*PETER LE NEVE FOSTER, M.A.	,, 1869.
*LIONEL S. BEALE, M.B., F.R.S.	,, 1870-1.
ROBERT BRAITHWAITE, M.D., F.L.S.	,, 1872-3.
*JOHN MATTHEWS, M.D., F.R.M.S.	,, 1874-5.
*HENRY LEE, F.L.S., F.G.S., F.R.M.S., F.Z.S.	,, 1876-7.
*THOS. H. HUXLEY, LL.D., F.R.S.	,, 1878.
*T. SPENCER COBBOLD, M.D., F.R.S., F.L.S.	,, 1879.
T. CHARTERS WHITE, M.R.C.S., L.D.S., F.R.M.S.	,, 1880-1.
M. C. COOKE, M.A., LL.D., A.L.S.	,, 1882-3.
*W. B. CARPENTER, C.B., F.R.S.	,, 1884.
A. D. MICHAEL, F.L.S., F.R.M.S.	,, 1885-6-7.
B. T. LOWNE, F.R.C.S., F.L.S.	Feb. 1888-9.
*Rev. W. H. DALLINGER, LL.D., F.R.S., F.R.M.S.	,, 1890-1-2.
EDWARD MILLES NELSON, F.R.M.S.	,, 1893-4-5.
*J. G. WALLER, F.S.A.	,, 1896-7.
JOHN TATHAM, M.A., M.D., F.R.M.S.	,, 1898-9.
GEORGE MASSEE, F.L.S.	Feb. 1900-1-2-3.
EDMUND J. SPITTA, L.R.C.P., M.R.C.S., F.R.A.S., F.R.M.S.	Feb. 1904-5-6-7.

* Deceased.

HONORARY MEMBERS.

Date of Election.	
Jan. 24, 1868.	Arthur Mead Edwards, M.D. *423, Fourth Avenue, Newark, New Jersey, U.S.A.*
Feb. 17, 1893.	Robert Braithwaite, M.D., F.L.S., F.R.M.S. (*Past President*) 26, *Endymion Road, Brixton Hill, S.W.*
Feb. 17, 1893.	M. C. Cooke, M.A., LL.D., A.L.S. (*Past President*) 53, *Castle Road, Kentish Town, N.W.*
Feb. 17, 1893.	T. Charters White, M.R.C.S., L.D.S., F.R.M.S. (*Past President*) 49, *Victoria Road South, Southsea.*
Mar. 19, 1897.	B. T. Lowne, M.D., F.R.C.S., F.L.S., etc. (*Past President*) *The Cedars, Crondall, near Farnham, Surrey.*
May 18, 1906.	Dr. Eugène Penard *Rue Töpffer 3, Geneva.*

LIST OF MEMBERS.

Date of Election.	
Feb. 16, 1906.	Abson, Herbert 14, *Gainsborough Road, Mile End, E.*
Feb. 16, 1906.	Akehurst, Sydney Charles (*Hon. Librarian*) 60, *Bowes Road, Palmer's Green, N.*
Feb. 19, 1904.	Allardice, Lieut. William McDiarmid *Tregenna Longcross, St. Endellion North, Cornwall.*
April 18, 1890.	Allen, J. M., F.R.M.S. 11, *Gray's Inn Square, W.C.*
May 24, 1910.	Allen, William Nassau *"Caerneagh," North Circular Road, Dublin.*
Dec. 15, 1899.	Angus, H. F. 83, *Wigmore Street, Cavendish Square, W.*
June 21, 1907.	Arpin, John Edward 131, *Castelnau, Barnes, S.W.*
Feb. 22, 1889.	Ashe, A., F.R.M.S. *Roman Villa, Laurie Square, Romford, Essex.*
Feb. 28, 1911.	Austin, Henry *Tudor House,* 120, *Greenwich Road, Greenwich, S.E.*
Dec. 15, 1899.	Ayrton, William *"The Cliff," Beccles, Suffolk.*
June 4, 1909.	Baddeley, William H. L. 29, *Church Crescent, Church End, Finchley, N.*
April 17, 1903.	Bagshaw, Walter, J.P., F.R.M.S. *"Moorfield," Birkenshaw, near Bradford, Yorks.*

Date of Election.	
Sept. 26, 1884.	Baker, F. W. W., F.R.M.S. 313, *High Holborn, W.C.*
Mar. 16, 1906.	Baker, Henry James 13, *Moorgate Street, E.C.*
April 2, 1909.	Baker, Wilfred E. Watson 313, *High Holborn, W.C.*
Mar. 20, 1908.	Banfield, Arthur Clive 13F, *Cornwall Mansions, N.W.*
June 19, 1908.	Banham, Edward Elliott 128, *Uxbridge Road, West Ealing, W.*
Mar. 21, 1902.	Barker, John W., B.Sc., A.R.C.S. 8, *Balcaskie Road, Eltham Park, Kent.*
Mar. 19, 1886.	Barnes, W. 23, *Jackson Road, Holloway, N.*
May 25, 1883.	Barratt, Thomas J., F.R.M.S. *Bell Moor House, Upper Heath, Hampstead, N.W.*
Feb. 16, 1900.	Barrett, R. H. *The Homestead, Berkhampsted.*
Sept. 27, 1872.	Bartlett, Edward, L.D.S., M.R.C.S.E. 38, *Connaught Square, W.*
June 16, 1905.	Barton, William Charles *Willeslie House*, 43, *Rosary Gardens, South Kensington, S.W.*
Feb. 28, 1911.	Bartrum, Walter Eccleston 10, *Argyll Road, Kensington, W.*
June 17, 1892.	Bates, C. 1, *Windsor Road, Denmark Hill, S.E.*
Oct. 18, 1895.	Baugh, J. H. A. 63, *Bambridge Road, Hammersmith, W.*
June 4, 1909.	Baxendale, Frederick G. 27, *Hawes Road, Bromley, Kent.*
Jan. 16, 1891.	Baxter, W. E., F.R.M.S. 170, *Church Street, Stoke Newington, N.*
June 19, 1908.	Bayliffe, John H. *The Moorings, Essex Road, Burnham-on-Crouch.*
Nov. 26, 1875.	Beaulah, John *Raventhorpe, Brigg.*

Date of Election.	
July 25, 1884.	Beck, C., F.R.M.S. 68, *Cornhill, E.C.*
June 27, 1911.	Bennett, Lionel C. 49, *Orpingham Road, Putney, S.W.*
Feb. 16, 1906.	Bestow, Charles H. 43, *Upper Clapton Road, N.E.*
Mar. 20, 1908.	Blackbourn, Basil *Hoo, Minster, near Ramsgate.*
June 16, 1905.	Blair, William Nisbet 23, *West Hill, Highgate, N.*
Oct. 2, 1908.	Blockley, Edgar A. 26, *Mayfield Avenue, Chiswick, W.*
May 19, 1899.	Blood, Maurice, M.A., F.C.S., F.R.M.S. 16, *Alexandra Road, Kingston Hill, Surrey.*
Dec. 28, 1909.	Bostock, John *Wadham House, Toynbee Hall, Commercial Street, E.*
April 25, 1911.	Bowtell, Alexander Jos. 137, *Dalston Lane, N.E.*
Oct. 28, 1893.	Boyes, William B., F.R.M.S. *P.O. Box* 1923, *Johannesburg, Transvaal.*
Nov. 15, 1907.	Bradford, William Barnes 65, *Tyrwhitt Road, St. John's, S.E.*
Nov. 17, 1905.	Bremner, John Unthank 277, *King Street, Hammersmith, W.*
Jan. 24, 1911.	Bridge, Samuel 28, *Larkhall Rise, Clapham, S.W.*
Nov. 23, 1909.	Bright, Charles Sibthorp 7, *Blenheim Crescent, South Croydon.*
Nov. 6, 1908.	Broad, John Moxon 2, *Nicoll Road, Harlesden, N.W.*
Feb. 17, 1905.	Brooks, Howard *Cedarhurst, St. Albans.*
Dec. 4, 1908.	Brooks, Theodore, F.R.M.S. *British Vice-Consul, Guantanamo, Cuba.*
Dec. 19, 1890.	Brough, J. R. 29, *Alexandra Villas, Finsbury Park, N.*
Mar. 15, 1907.	Browett, William *"Beaumont," Pearfield Road, Forest Hill, S.E.*

Date of Election.	
May 24, 1910.	Brown, Edward George 8, *Freke Road, Battersea, S.W.*
Jan. 18, 1907.	Brown, Nicholas Edward 6, *The Avenue, Kew.*
Jan. 28, 1887.	Browne, E. T., B.A., F.R.M.S. *Anglefield, Berkhampsted, Herts.*
Mar. 18, 1904.	Brushfield, N. W. 13, *Allfarthing Lane, Wandsworth Common, S.W.*
Jan. 15, 1892.	Bryce, D. 37, *Brooke Road, Stoke Newington, N.*
May 23, 1911.	Bunnin, Charles A. 8, *Clarence Gardens, Clapton, N.E.*
May 15, 1908.	Bunting, Percival J. *Lindley, O.R.C., South Africa.*
Jan. 20, 1905.	Burnell, Charles Edward 29, *High Street, Shepton Mallet.*
April 20, 1906.	Burrell, T. Leonard 20, *Upper Hornsey Rise, Islington, N.*
Feb. 19, 1904.	Burton, James 8, *Somali Road, West Hampstead, N.W.*
Jan. 15, 1904.	Butcher, Lewis 82, *Barn Mead Road, Beckenham, Kent.*
Jan. 24, 1911.	Butcher, Thomas William, M.B., C.M., F.R.M.S. 3, *Clifton Street, Blackpool.*
Feb. 19, 1904.	Butterworth, Arthur Cyrus, F.R.M.S. *Glanville, Crowstone Road, Westcliff-on-Sea.*
April 15, 1904.	Caffyn, Charles Henry (*Hon. Assistant Librarian*) 32, *Falkland Road, Hornsey, N.*
June 18, 1897.	Campbell, Colney 47, *Selborne Road, Southgate, N.*
April 25, 1911.	Campling, Bernard John 22, *Vicarage Villas, Neasden, N.W.*
Jan. 25, 1910.	Canaway, Robert 21, *New Street, Salisbury.*

Date of Election.	
Mar. 16, 1906.	Capell, Bruce John 10, *Castelnau, Barnes, S.W.*
Jan. 20, 1905.	Carrington, John *P.O. Box* 48, *East London, South Africa.*
May 24, 1910.	Carruthers, Ferdinand Gilbert 10, *Addison Road, Bedford Park, W.*
Jan. 25, 1910.	Carter, John Arthur 5, *Unity Road, Stowmarket.*
June 17, 1892.	Chaloner, G., F.C.S. *Combe House, Colyton, Axminster.*
Mar. 17, 1905.	Chapman, David Leighton 100, *Tooley Street, S.E.*
June 28, 1910.	Charlton, Alfred Edward 23, *North Villas, Camden Square, N.W.*
Oct. 26, 1909.	Cheavin, Harold Squire 70, *Somerset Road, Huddersfield.*
Mar. 22, 1878.	Chester, The Very Rev. the Dean of *The Deanery, Chester.*
Dec. 18, 1896.	Chipps, F. W. 201, *Castelnau, Barnes, S.W.*
Jan. 20, 1905.	Christie, John, F.R.M.S. *Henleighs, Kingston Hill, Surrey.*
May 18, 1906.	Churchouse, G. 30, *Natal Road, Bowes Park, N.*
May 15, 1903.	Cleave, A. H. W., F.R.M.S. *Royal Mint, Ottawa, Canada.*
Mar. 17, 1905.	Clemence, Walter *Farringford, Walton-on-Thames.*
Oct. 18, 1907.	Coldwells, William Henry *Redcote, Shirley Road, Wallington.*
Mar. 28, 1911.	Coleman, Chas. 10, *Winterton Road, Sydenham, S.E.*
Mar. 5, 1909.	Collier, Oswald *The Hermitage, Snaresbrook.*
Nov. 16, 1906.	Collins, Brenton Robie, M.A. *Gorsebrook, Matfield, Paddock Wood, Kent.*
Oct. 21, 1904.	Conrady, Alexander Eugen, F.R.A.S., F.R.M.S. 23, *Flanchford Road, Stamford Brook, W.*

Date of Election.	
May 28, 1869.	Cottam, Arthur, F.R.A.S. *Furze Bank, Durleigh Road, Bridgwater.*
April 20, 1906.	Couch, Robert Percy " *Montrose,*" 44, *Radcliffe Road, Winchmore Hill, N.*
Jan. 18, 1901.	Cox, Thomas N., jun. 104, *Tressillian Road, Brockley, S.E.*
Jan. 15, 1904.	Cox, William 113, *Manor Road, Brockley, S.E.*
June 19, 1903.	Coxhead, G. W. 5A, *Springfield Gardens, Upper Clapton, N.E.*
Jan. 25, 1910.	Crabtree, James Fox, B.A. 40, *Brazennose Street, Manchester.*
Dec. 20, 1901.	Craig, Thomas, F.R.M.S. 26, *Selkirk Avenue, Montreal, Canada.*
Nov. 21, 1902.	Cressey, Dr. G. H. *Oak Manor, Tonbridge.*
Aug. 28, 1868.	Crisp, Sir Frank, LL.B., V.P.L.S., B.A., F.R.M.S., F.G.S., F.Z.S., 5, *Lansdowne Road, Notting Hill, W.*
Mar. 20, 1908.	Croger, Frank Clifford 114, *Wood Street, E.C.*
Nov. 16, 1906.	Crosbie, Walter *Kenilworth, Lyonsdown Avenue, New Barnet.*
Jan. 25, 1910.	Cross, Edward 1, *Burghley Road, Hornsey, N.*
Feb. 16, 1900.	Crossland, R. E., A.R.I.B.A. 10, *Serjeant's Inn, Fleet Street, E.C.*
Dec. 21, 1906.	Cullin, William George 182, *Tottenham Court Road, W.*
Mar. 16, 1894.	Culshaw, Rev. George H., M.A. *The Rectory, Iver Heath, Bucks.*
April 18, 1902.	Cumming, John 29, *Ella Road, Crouch End, N.*
June 25, 1880.	Curties, C. Lees, F.R.M.S. 244, *High Holborn, W.C.*
Jan. 16, 1903.	Curtis, C. L., jun. 244, *High Holborn, W.C.*

Date of Election.	
May 18, 1906.	Cuzner, Edgar 36, *Trothy Road, Bermondsey, S.E.*
Nov. 18, 1904.	Dade, Willoughby Dreyer 6, *Montague Road, Richmond, Surrey.*
Jan. 17, 1908.	Dallas, Charles Caldwell, F.R.G.S., F.Z.S. *Eastley Wootton, New Milton, Hants.*
Dec. 21, 1906.	Darlaston, Herbert William Hutton 31, *Freer Road, Birchfield, Birmingham.*
Mar. 15, 1895.	Daunou, F. 1, *Shirley Villas, Westbrook, Margate.*
Feb. 28, 1911.	Davidson, John 29, *Federation Road, Abbey Wood, Kent.*
Nov. 22, 1910.	Davidson, Rev. Martin 56, *Hudson's Road, Canning Town, E.*
June 16, 1905.	Davies, Daniel, F.R.M.S. 12, *Eliot Hill, Blackheath, S.E.*
May 18, 1906.	Davies, E. Ayerst 124, *Croydon Road, Anerley, S.E.*
Jan. 19, 1906.	Davies, Perceval Eckton *Abbeydale, Marmora, Road, Honor Oak, S.E.*
May 17, 1901.	Deeley, George P. *Moushall, Amblecote, Brierley Hill, Staffordshire.*
April 19, 1895.	Delcomyn, Theo. A., F.R.M.S. "*Feldheim,*" *Wimbledon Common, S.W.*
Nov. 17, 1893.	Dennis, A. W. 56, *Romney Buildings, Milbank, S.W.*
Mar. 22, 1889.	Dick, J. *Milber, Victoria Road, Mill Hill, N.W.*
Feb. 15, 1907.	Dilks, Arthur Charles *Tardebigge, Bromsgrove.*
June 4, 1909.	Dixon, Arthur L. 35, *North Hill, Highgate, N.*
June 17, 1892.	Dixon-Nuttall, F. R., F.R.M.S. "*Ingleholme,*" *Eccleston Park, near Prescot, Lancashire.*
Jan. 1, 1909.	Dodd, Frederick H., F.R.M.S. 51, *Shooters Hill Road, Blackheath, S.E.*

Date of Election.

Feb. 22, 1910. Doughten, William S.
415, *Race Street, Philadelphia, Pa., U.S.A.*
Oct. 25, 1910. Douglas, William
Diamond, Demerara, B.W.I.
Mar. 17, 1899. Downs, Arthur
2, *Woodside Villas, Ulverston Road, Walthamstow.*
Nov. 23, 1909. Draper, Bernard M.
9, *Pitt Street, Kensington, W.*
May 17, 1907. Drinkwater, Jesse, F.R.M.S.
St. Margaret's, Stanley Gardens, Wallington.
Nov. 15, 1901. Druett, C. R.
330, *Uxbridge Road, W.*
Dec. 28, 1909. Dumat, Frank C.
1, *Tedworth Gardens, S.W.*
June 4, 1909. Dunkerly, John S., B.Sc.
Natural History Department, University of Glasgow.
Feb. 22, 1910. Dunstall, George Kirkman
39, *Redcross Street, E.C.*

June 19, 1891. Earland, Arthur, F.R.M.S.
Reading Villa, Denmark Street, Watford.
May 15, 1908. East, John Holtham
46, *Cherington Road, Hanwell, W.*
Sept. 25, 1868. Eddy, J. R., F.R.M.S., F.G.S.
The Grange, Carleton, Skipton, Yorkshire.
Feb. 21, 1902. Edwards, Thomas Jarvis
9, *St. Lawrence Road, Brixton, S.W.*
Mar. 22, 1910. Ellis, William Neale
6, *Clarence Road, Kew Gardens.*
May 26, 1876. Emery, Charles
10, *Barrington Road, Crouch End, N.*
April 17, 1896. Enock, F., F.L.S., F.R.M.S., F.E.S.
13, *Tufnell Park Road, Holloway, N.*
Feb. 28, 1879. Epps, Hahnemann
95, *Upper Tulse Hill, Brixton, S.W.*
Dec. 20, 1907. Evans, Benjamin
162, *Battersea Bridge Road, S.W.*

Date of Election.

Nov. 17, 1905. Evans, Morris B.
33, *Lady Margaret Road, Southall, Middlesex.*
May 5, 1909. Ewell, Dr. Marshall D., F.R.M.S.
59, *Clark Street, Chicago, Ill., U.S.A.*

Dec. 21, 1906. Fawcett, Henry Hargreave
c/o P. N. Fawcett, Heorthfest, Ridgway, Wimbledon, S.W.
June 16, 1893. Filer, Frank E.
35, *Dancroft Road, Herne Hill, S.E.*
Feb. 19, 1904. Finlayson, Daniel
“*Redfern*,” *Pellatt Grove, Wood Green, N.*
June 19, 1908. Flamank, Sydney W.
Church House, Dean's Yard, Westminster, S.W.
Nov. 23, 1888. Flood, W. C.
119, *Highbury Hill, N.*
June 23, 1871. Freeman, H. E.
Walcot, Limes Avenue, New Southgate, N.
Jan. 18, 1901. Freeman, Rev. Richard, M.A.
Whitwell Vicarage, Reepham, Norfolk.
Dec. 16, 1898. French, Archibald J.
10, *Radford Road, Lewisham, S.E.*
Jan. 18, 1907. Fuelling, George Ernest
195, *High Road, Streatham, S.W.*
Feb. 22, 1910. Fuller, Frederick Charles
9, *Goldington Road, Bedford.*
Nov. 21, 1902. Fuller, William
24, *Coleford Road, Alma Road, Wandsworth, S.W.*

May 15, 1903. Gabb, G. H., F.C.S.
83, *Crayford Road, Tufnell Park, N.*
Dec. 15, 1905. Gardner, Edward Lewis
1, *Craven Road, Harlesden, N.W.*
Jan. 20, 1899. Gardner, William, F.R.M.S.
292, *Holloway Road, N.*
Nov. 22, 1910. Garner, William George
35, *Marlborough Road, Wimbledon Park.*

Date of Election.	
Dec. 16, 1904.	Garnett, Theodore, M.A. Oxon *South Bank, Grassendale, Liverpool.*
May 17, 1901.	Gladding, Harold 39, *Dowkin Street, Port Elizabeth, Cape Colony.*
Nov. 22, 1910.	Gladstone, Reginald J., M.D. 1, *Gloucester Gate, Regent's Park, W.*
Mar. 22, 1910.	Gonville, Cyril H. K. "*Milton,*" *Queen's Road, Buckhurst Hill, N.*
Dec. 28, 1909.	Gooding, Henry Cornish *Stowmarket, Suffolk.*
April 2, 1909.	Gordon, Fred William, F.R.M.S. "*Woodfield,*" *Lytton Grove, Putney Hill, S.W.*
Feb. 22, 1910.	Gordon, John W. 113, *Broadhurst Gardens, Hampstead, N.W.*
May 17, 1907.	Graham, Charles E. 15, *River Avenue, Palmer's Green, N.*
Nov. 15, 1907.	Gray, W. 5, *Stapleton Road, Upper Tooting, S.W.*
Nov. 17, 1899.	Green, E. E. *Peradeniya, Ceylon.*
Jan. 25, 1910.	Green, Frederick N. 40, *Lombard Street, E.C.*
Jan. 16, 1903.	Green, H. O. 4, *Leamington Gardens, Seven Kings.*
Mar. 22, 1910.	Green, William 6, *Meredith Street, E.C.*
Nov. 18, 1898.	Grocock, L. O. 167, *Venner Road, Sydenham, S.E.*
May 17, 1895.	Groves, H., F.L.S. 21, *Sibella Road, Clapham Rise, S.W.*
May 24, 1910.	Grundy, James 8, *Grosvenor Gardens, Cricklewood, N.W.*
Feb. 19, 1904.	Gurney, Robert *Ingham Old Hall, Stalham, Norfolk.*

Date of Election.	
Sept. 28, 1888.	Hall, T. F. *North Audley House, North Audley Street, W.*
Feb. 20, 1903.	Hall, W. D. "*Monte Rosa,*" 87, *Stradella Road, Herne Hill, S.E.*
Feb. 22, 1910.	Hammond, Alfred Gauntlett 101, *Melody Road, Wandsworth, S.W.*
Jan. 25, 1910.	Hammond, Arthur Rashdall 15, *Genoa Road, Anerley, S.E.*
April 26, 1910.	Hammond, Leonard Frank 22, *Mercers Road, N.*
Oct. 22, 1886.	Hampton, W. *The Manor House, Weston, Staffordshire.*
Nov. 22, 1910.	Harris, A. Wellesley, M.R.C.S., etc. "*Alnwick,*" *Berlin Road, Catford, S.E.*
May 19, 1905.	Harris, Charles Poulet, M.D., M.R.C.S., L.R.C.P., F.R.M.S. 98, *Lower Addiscombe Road, Croydon.*
May 17, 1901.	Harvey, Sidney, F.I.C., F.C.S. *Watling House, Canterbury.*
Dec. 21, 1906.	Hasslacher, Charles John 3, *Kensington Park Gardens, W.*
Mar. 28, 1879.	Hawkins, C. E. 23, *Dalebury Road, Upper Tooting, S.W.*
Feb. 15, 1901.	Headley, F. W. *Haileybury College, Hertford.*
Jan. 19, 1906.	Heath, Charles Emanuel, F.R.M.S. 178, *Loughboro' Road, Brixton, S.W.*
Feb. 5, 1909.	Hebdon, William 181, *Breakspears Road, Brockley, S.E.*
April 20, 1906.	Herbert, Robert Henry 32, *Fairmead Road, Holloway, N.*
Feb. 21, 1908.	Heron-Allen, Edward, F.L.S., F.R.M.S., F.R.Met.S., F.Z.S. 3, *Northwich Terrace, Maida Hill, N.W.*
Dec. 20, 1901.	Hicks, Frederick H. *Belmont Villas, Wallington, Surrey.*
Dec. 22, 1910.	Higginson, George Neale 97, *Gower Street, W.C.*

Date of Election.	
Feb. 17, 1899.	Hill, Edward J. *Darnlee, Melrose, N.B.*
Nov. 15, 1895.	Hilton, A. E. 21, *Ashmount Road, Upper Holloway, N.*
May 15, 1908.	Hiscott, Thomas Henry, F.R.M.S. 16, *Woodville Road, Ealing, W.*
Nov. 16, 1906.	Hocking, William John *Royal Mint, E.*
Dec. 15, 1893.	Holder, J. T. 114, *Pepys Road, New Cross, S.E.*
Feb. 26, 1875.	Holford, Christopher 5, *Northumberland Avenue, Upper Richmond Road, Putney, S.W.*
Dec. 20, 1907.	Holmes, Frederick "*Salerno,*" *Stanley Road, Woodford, Essex.*
Jan. 15, 1904.	Hopkinson, John, F.L.S., F.G.S., F.R.M.S. *Weetwood, Watford.*
Oct. 26, 1866.	Horncastle, Henry "*Lindisaye,*" *Woodham Road, Woking.*
April 15, 1898.	Hounsome, John 21, *Edith Road, Plashet Grove, East Ham, E.*
Nov. 19, 1897.	Howard, Arthur 60, *Palace Gardens Terrace, W.*
Dec. 4, 1908.	Howard, George, *Sitwell Vale, Moorgate, Rotherham, Yorks.*
Oct. 19, 1894.	Howard, R. N., M.R.C.S., F.R.M.S. *The Cape Copper Co., Ookiep, Port Nolloth, Namaqualand, Cape Colony, South Africa.*
Oct. 19, 1894.	Hughes, F. *Wallfield, Reigate.*
May 28, 1886.	Hughes, W. 32, *Heathland Road, Stoke Newington, N.*
Nov. 23, 1909.	Huish, Charles Henry 23, *Champion Grove, Grove Lane, S.E.*
June 4, 1909.	Hunter, John E. "*Strathblane,*" *Park Road, Wallington.*

Date of Election.	
Dec. 20, 1901.	Hurrell, Harry Edward 25, *Regent Street, Great Yarmouth.*
May 24, 1867.	Ingpen, J. E., F.R.M.S. *St. John's, Wrotham Road, Broadstairs.*
Feb. 16, 1906.	Inwards, Richard, F.R.A.S. 6, *Croftdown Road, Highgate Road, N.W.*
Feb. 28, 1911.	Jacob, Hugh Frederick Dawson, M.I.E.E. *c/o Jessop & Co., Ltd.*, 93, *Clive Street, Calcutta.*
April 26, 1910.	Jervis, Rev. Edward S. *St. Peter's Vicarage, Streatham, S.W.*
Nov. 22, 1910.	Jewell, Henry 152, *Leathwaite Road, Clapham Common, S.W.*
Nov. 17, 1905.	Jones, Arthur Morley 11, *Eaton Rise, Ealing, W.*
April 26, 1910.	Jones, George Fisher *Devonshire House, Osterley Park Road, Southall, W.*
Jan. 18, 1907.	Jones, Rev. Robert Francis 97, *Fort Road, Bermondsey, S.E.*
Feb. 22, 1910.	Jones, William Llewellyn *Manley Knoll, Helsby, Cheshire.*
Feb. 22, 1910.	Joshua, Edward Cecil *St. James's Buildings, William Street, Melbourne, Victoria.*
Nov. 17, 1905.	Karleese, Benjamin *The Dell, Barnt Green, Worcestershire.*
May 23, 1873.	Karop, G. C., M.R.C.S., F.R.M.S., etc. *Inniscorig, Beltinge Road, Herne Bay.*
June 21, 1907.	Kemp, Francis H. N. C. 15, *Vernon Road, Hornsey, N.*
July 25, 1884.	Kern, J. J. *"Fern Glen," Selhurst Park, South Norwood, S.E.*
Nov. 18, 1904.	Kew, H. Wallis 3, *Herndon Road, Wandsworth, S.W.*

Date of Election.	
May 17, 1901.	Kingsford, T. G. 1, *Fortescue Villas, Stafford Road, Wallington, Surrey.*
May 17, 1901.	Kirkman, Hon. Thomas, M.L.C., F.R.M.S. Croftlands, Esperanza, Natal.
May 19, 1905.	Kitchin, Joseph, F.R.M.S. "*Ingleneuk,*" 14, *Brackley Road, Beckenham, Kent.*
Mar. 22, 1889.	Klein, S. T., F.R.A.S., F.L.S., F.R.M.S. "*Hatherlow,*" *Raglan Road, Reigate.*
June 19, 1908.	Knaggs, Henry V., L.R.C.P. Edin., M.R.C.S. Eng. 189, *Camden Road, N.W.*
Dec. 28, 1909.	Knox, Sydney W. 61, *Cambridge Street, Hyde Park, W.*
Feb. 17, 1905.	Lambert, Charles Alexander *Bank of New South Wales, Warwick, Queensland.*
Jan. 18, 1907.	Larkin, Thomas Gaisford 29, *Thornlaw Road, West Norwood, S.E.*
April 26, 1910.	Lascelles, The Honble. William H. *The Weton Grange, Scole, Norfolk.*
June 17, 1904.	Lawrence, Frederick George *c/o Lionel Samson & Son, Cliff Street, Fremantle, West Australia.*
April 26, 1910.	Lawrence, William John 5, *Rebecca Terrace, Rotherhithe, S.E.*
Mar. 16, 1900.	Lawson, Peter, "*Jesmond Dene,*" 87, *Finlay Street, Fulham, S.W.*
Jan. 1, 1909.	Leadbeater, Herbert C. 38, *Galveston Road, East Putney, S.W.*
Jan. 20, 1905.	Lees, Rev. Frederick Clare, 45, *Cavendish Road, Sutton, Surrey.*
Nov. 21, 1902.	Leonard, Edward 2, *Cannon Mount, Claughton, Cheshire.*
Nov. 17, 1905.	Levett, Rev. Robert Kennedy, F.R.M.S. *Ingram Gate, Thirsk, Yorkshire.*

Date of Election.	
Jan. 17, 1908.	Levin, Arthur Everard *"Hillcroft," Shawfield Park, Bromley, Kent.*
Nov. 25, 1887.	Lewer, J. J. 5, *Mowbray Road, Brondesbury, N.W.*
Feb. 22, 1910.	Lewis, Frederic Henry *"Ashmore," King's Avenue, Clapham Park, S.W.*
April 27, 1866.	Lewis, R. T., F.R.M.S. (*Hon. Reporter*) 41, *The Park, Ealing, W.*
June 26, 1868.	Lindley, W. H., jun. 29, *Blittersdorffs Platz, Frankfort-on-Main.*
Jan. 18, 1907.	Lyon, Massey, F.R.M.S. *c/o Messrs. Coutts,* 440, *Strand, W.C.*
Nov. 23, 1909.	Maclean, Robert Colquhoun 36, *Avenue Road, Highgate, N.*
Feb. 22, 1910.	McCulloch, Leslie Royal 99, *Coldershaw Road, West Ealing.*
May 25, 1883.	Mainland, G. E., F.R.M.S. 14, *The Norton, Tenby, South Wales.*
June 17, 1898.	Marks, Kaufmann J., F.R.M.S. 4, *Woodchurch Road, West Hampstead, N.W.*
Jan. 24, 1911.	Marsh, George Robertson, M.A. *Mallards Close, Twyford, near Winchester, Hants.*
Feb. 15, 1895.	Marshall, William John, F.R.M.S. 20, *Emlyn Road, Shepherd's Bush, W.*
Mar. 20, 1896.	Martin, Herbert Sydney 10, *Arngask Road, Catford, S.E.*
May 18, 1906.	Martin, William *"Kethlen," Burgh Heath, Epsom, Surrey.*
Nov. 18, 1898.	Massee, G., F.L.S. *Royal Gardens, Kew.*
April 26, 1867.	Matthews, G. K. *St. John's Lodge, Beckenham, Kent.*
Jan. 15, 1892.	Maw, W. H., F.R.M.S., F.R.A.S. 18, *Addison Road, Kensington, W.*

Date of Election.	
Mar. 28, 1911.	Maxwell, Edmond Kelly, B.A., *H.M. Patent Office, W.C.*
May 19, 1893.	Merlin, A. A. C. Eliot, F.R.M.S. *British Consulate, Volo, Greece.*
Oct. 18, 1907.	Mestayer, Richard L., M.I.C.E., F.R.M.S. *Lambton Quay, Wellington, New Zealand.*
July 27, 1877.	Michael, A. D., F.L.S., F.R.M.S. *The Warren, Studland, near Wareham, Dorset.*
July 7, 1865.	Millett, F. W., F.G.S., F.R.M.S. *Eniscoe, Brixham, Devon.*
Jan. 20, 1905.	Milne, William *Uitenhage, Cape Colony, South Africa.*
Oct. 18, 1907.	Minchin, Edward Alfred, M.A., F.R.S., (*President*) 53, *Cheyne Court, Royal Hospital Road, Chelsea, S.W.*
Oct. 18, 1901.	Moore, Harry, F.R.M.S. 12, *Whiston Grove, Moorgate, Rotherham, Yorks.*
July 26, 1878.	Morland, Henry *Cranford, near Hounslow.*
Oct. 26, 1909.	Morris, Capel *"Llafield," Gibson's Hill, Norwood, S.E.*
Oct. 25, 1910.	Morris, Charles Barham *Waitaki Pharmacy, Thames Street, Oamaru, N.Z.*
June 4, 1909.	Mortimer, Hugh Hamilton 20, *Birchin Lane, E.C.*
Jan. 16, 1891.	Muiron, C. 49, *Chatsworth Road, Brondesbury, N.W.*
Nov. 22, 1910.	Mummery, J. Howard, M.R.C.S. *Islips Manor, Northolt, Middlesex.*
June 16, 1905.	Myles, James Cellars 53, *Carlyle Road, Manor Park, S. Essex.*
Mar. 24, 1876.	Nelson, E. M., F.R.M.S. *Beckington, Bath.*
May 16, 1902.	Nevill, Rev. T. J., F.R.M.S. 2, *Grange Road, Eastbourne.*

Date of Election.	
Feb. 15, 1907.	Newman, Charles Arnold *Oundle, Northants.*
Jan. 26, 1872.	Newton, E. T., F.R.S., F.G.S. *Florence House, Willow Bridge Road, Canonbury, N.*
Jan. 17, 1908.	Nicholson, Alfred 7, *Belton Road, Sidcup.*
June 15, 1894.	North, The Right Honble. Sir Ford, F.R.S., F.R.M.S. (*Vice-President*) 76, *Queensborough Terrace, Bayswater, W.*
June 4, 1909.	Oakenfull, Perrin 25, *The Gardens, Peckham Rye, S.E.*
Feb. 16, 1900.	O'Donohoe, T. A. 8, *Myrtle Road, Acton, W.*
Jan. 24, 1879.	Offord, J. M., F.R.M.S. 3, *Cleveland Gardens, West Ealing, W.*
Dec. 22, 1876.	Ogilvy, C. P., F.L.S. *Sizewell House, Leiston, near Saxmundham, Suffolk.*
May 17, 1907.	Ogilvy, J. Wilson, F.R.M.S. 9, *Oxford Street, W.*
Nov. 15, 1907.	Oke, Alfred William, B.A., LL.M. 32, *Denmark Villas, Hove.*
Nov. 18, 1892.	Orfeur, Frank, F.R.M.S. 91, *Effra Road, Brixton, S.W.*
Dec. 27, 1867.	Oxley, Frederick, F.R.M.S. *c/o A. E. Linton, Esq., Box* 9, *P.O., Nairobi, British East Africa.*
Dec. 18, 1903.	Oxley, F. J., M.R.C.S. 1, *Dock Street, E.*
April 10, 1910.	Parfitt, Edward William 7, *Galcombe Road, Tufnell Park, N.*
Oct. 27, 1871.	Parsons, F. A. 15, *Osborne Road Finsbury Park, N.*
Dec. 16, 1904.	Patterson, George *The Flat, The Manbre Saccharine Co., Limited, Fulham Palace Road, Hammersmith, W.*

Date of Election.	
July 23, 1886.	Paul, R., Holmbush, *Cyprus Road, Exmouth, Devon.*
Jan. 18, 1901.	Paulson, Robert, F.R.M.S. *"Hosey," Cheney Lane, Pinner, Middlesex.*
May 24, 1867.	Pearson, John 40, *Maida Vale, W.*
May 23, 1911.	Pells, Cyril E., 244, *High Holborn, W.C.*
May 20, 1904.	Perks, Frederick John (*Hon. Treasurer*) 48, *Grove Park, Denmark Hill, S.E.*
Dec. 21, 1906.	Perrin, Charles Seale *Claremont, Queen's Road, Newbury, Berks.*
Jan. 18, 1907.	Perry, Francis Gough 2, *The Cloisters, Gordon Square, W.C.*
Mar. 17, 1905.	Phipps, William Joseph 132, *Pinner Road, Oxhey, Herts.*
Feb. 20, 1903.	Pilcher, Charles Frederick 30, *Upton Avenue, Forest Gate, E.*
Nov. 15, 1895.	Pillischer, J., F.R.M.S. 88, *New Bond Street, W.*
April 25, 1910.	Pinchin, Ernest Alfred, B.Sc., 4, *Gleneldon Road, Streatham, S.W.*
Nov. 19, 1897.	Pittock, George Mayris, M.B., F.R.M.S. *Winton, Whitstable Road, Canterbury.*
Jan. 15, 1904.	Pledge, John H., F.R.M.S. (*Hon. Assistant Secretary*) 23, *Canterbury Road, West Croydon, Surrey.*
Nov. 23, 1883.	Plowman, T. *Nystuen Lodge, Bycullah Park, Enfield.*
Sept. 21, 1894.	Pollard, Jonathan, F.R.M.S. 10, *Porteus Road, Paddington Green, W.*
May 18, 1900.	Poser, M., F.R.M.S. 13–14, *Great Castle Street, Oxford Circus, W.*
June 21, 1895.	Poulter, Christopher S. *Mount Lodge, Parkhurst Road, Bexley, Kent.*

Date of Election.	
Feb. 17, 1899.	Powell, Arthur 28, *Stafford Terrace, Kensington, W.*
May 17, 1901.	Powell, David, M.A., F.R.M.S. *Overstrand, Grove Park Road, Chiswick, W.*
July 7, 1865.	Powell, Thomas H., F.R.M.S. *Emsdale, Greenham Road, Muswell Hill, N.*
Dec. 20, 1907.	Pratt, John Edwin
June 4, 1909.	Pring, S. W. *Caversham, Newport, Isle of Wight.*
Feb. 28, 1911.	Pullman, John *The Knollsea, Lilliput, Dorset.*
Nov. 6, 1908.	Quick, Albert Hedley "*Inverness,*" *Malvern Road, Thornton Heath.*
Jan. 18, 1901.	Radley, Percy E., F.R.M.S. 30, *Foxgrove Road, Beckenham, Kent.*
Nov. 16, 1906.	Reid, Dr. Duncan J. 20, *Blakesley Avenue, Ealing.*
Mar. 20, 1896.	Rheinberg, Julius, F.R.M.S. 23, *The Avenue, Brondesbury Park, N.W.*
Sept. 18, 1891.	Richards, F. W. 212, *Notre Dame Street West, Montreal, Canada.*
Oct. 2, 1908.	Richards, William 3, *Favart Road, Fulham, S.W.*
Jan. 18, 1901.	Richardson, John 30, *Beaumont Avenue, Richmond, Surrey.*
Nov. 6, 1908.	Rink, Max 9, *Cannon Place, Christchurch, Hampstead, N.W.*
Feb. 28, 1911.	Ritchie, John, jun. 18, *Townhead, Beith, Ayrshire, N.B.*
June 21, 1901.	Robertson, H. R., F.R.M.S. *Upton Grange, Chester.*
Mar. 15, 1907.	Robertson, James Alexander, F.R.M.S. *Lune View, Fleetwood.*

Date of Election.

Nov. 16, 1900. Rogers, G. H. J., F.R.M.S.
55, King Street, Maidstone.

June 4, 1909. Rolph, Frank
Hartz Stables, Woodford Green, E.

Jan. 25, 1884. Rosseter, T. B., F.R.M.S.
East Kent Club, Canterbury.

Jan. 26, 1883. Rousselet, Charles F. (*Vice-President and Hon. Secretary for Foreign Correspondence*), Curator R.M.S.
Fir Island, Mill Hill, N.W.

Nov. 18, 1904. Rowley, Frederick Richard, F.R.M.S.
8, Pinhoe Road, Heavitree, Exeter.

April 27, 1888. Russell, J.
16, Blacket Place, Newington, Edinburgh.

Nov. 21, 1902. Sanderson, R. Z.
26, Baronsfield Road, St. Margaret's, E. Twickenham, Middlesex.

April 2, 1909. Saxton, Thomas R., A.M.I.C.E., F.R.M.S.
43, East Bank, Stamford Hill, N.

Dec. 21, 1906. Scorer, Alfred George,
Abercorn Lodge, Upper Hamilton Terrace, N.W.

June 20, 1890. Scourfield, D. J., F.Z.S., F.R.M.S. (*Vice-President*)
63, Queen's Road, Leytonstone, E.

May 20, 1898. Sears, Robert S. W.
1, Lisson Grove, N.W.

Dec. 4, 1908. Sharpe, F. E.
28, Balham Park Road, S.W.

Nov. 6, 1908. Sharp, W. Marmaduke
"Merivale," Gayton Road, Harrow.

Jan. 25, 1910. Sheldrick, Sidney Croston
9, Gatcombe Road, Tufnell Park, N.

Dec. 28, 1909. Shephard, John
Clark Street, Melbourne, Victoria.

May 26, 1876. Shepheard, Thomas, F.R.M.S.
Kingsley, Bournemouth West.

Date of Election.	
June 21, 1907.	Sheppard, Alfred William, F.R.M.S. (*Hon. Editor*) 1, *Vernon Chambers, W.C.*
Feb. 28, 1911.	Sidebottom, Henry "*Woodstock,*" *Syddal Park, Bramhall, Cheshire.*
June 19, 1896.	Sidwell, Clarence J. H., F.R.M.S. (*Hon. Curator*) 46, *Ashbourne Grove, Dulwich, S.E.*
Feb. 22, 1910.	Simpson, Norman Douglas Carlton *Mincott Vicarage, Thirsk, Yorks.*
Oct. 26, 1903.	Skorikow, Alexander Stepanovic *Musée Zoologique de l'Académie Impériale des Sciences, St. Petersburg, Russia.*
May 25, 1866.	Smith, Alpheus 14, *Leigham Vale, Streatham, S.W.*
Oct. 21, 1904.	Smith, Arthur Edgar "*Helios,*" 71, *Fox Lane, Palmer's Green, N.*
Mar. 25, 1870.	Smith, F. L. 3, *Grecian Cottages, Crown Hill, Norwood, S.E.*
Mar. 17, 1899.	Smith, Frank P. 5, *Gibson Square, Islington, N.*
Mar. 17, 1905.	Smith, Frederick 13, *Rye Hill Park, Peckham Rye, S.E.*
Nov. 18, 1898.	Smith, Thomas J., F.R.M.S. *c/o W. Watson & Sons,* 313, *High Holborn, W.C.*
Jan. 15, 1892.	Soar, C. D., F.R.M.S., F.L.S. 37, *Dryburgh Road, Putney, S.W.*
May 17, 1901.	Soutter, Andrew G., F.R.M.S. 17, *Beaulieu Villas, Finsbury Park, N.*
April 21, 1899.	Spitta, Edmund J., L.R.C.P., M.R.C.S., F.R.A.S., F.R.M.S. (*Vice-President*) 41, *Ventnor Villas, Hove, Brighton.*
April 21, 1899.	Spitta, Harold R. D., M.D., M.R.C.S., L.R.C.P., D.P.H. 12, *Bolton Street, Mayfair, W.*

Date of Election.	
Jan. 15, 1904.	Sprague, T. B., LL.D. 29, *Buckingham Terrace, Edinburgh.*
Jan. 18, 1907.	Stahl, Arthur 110, *Ravensbourne Road, Shortlands, Kent.*
Nov. 16, 1906.	Stephens, Samuel Phillips 15, *Green Street, Kimberley, Cape Colony.*
Nov. 17, 1899.	Stevens, John, F.R.M.S. 50, *St. David's Hill, Exeter.*
Nov. 27, 1885.	Stevenson, G. T. *Ravenscroft, Haling Park Road, South Croydon.*
June 18, 1897.	Still, Arthur L. *Sunnyside, Blakehall Road, Carshalton.*
Nov. 16, 1894.	Stokes, William B. (*Hon. Secretary*) 4, *Winn Road, Burnt Ash Hill, Lee, S.E.*
Dec. 15, 1893.	Sturt, Gerald "*Lismore,*" *Cavendish Road, Weybridge.*
June 24, 1870.	Swain, Ernest *Little Nalders, Chesham, Bucks.*
May 17, 1895.	Swan, Michael Edward *Brazil House, Taplow.*
Dec. 17, 1875.	Swift, M. J., F.R.M.S. 6, *Aylestone Avenue, Brondesbury, N.W.*
Nov. 28, 1879.	Tasker, J. G. 30, *Junction Road, Upper Holloway, N.*
Oct. 16, 1896.	Taverner, Henry, F.R.M.S. 319, *Seven Sisters Road, Finsbury Park, N.*
May 24, 1910.	Taylor, Charles 178, *Uxbridge Road, West Ealing.*
Feb. 17, 1905.	Taylor, Thomas George *Ballaclague, Ellington Park Road, Ramsgate.*
Dec. 22, 1865.	Terry, John 8, *Hopton Road, Coventry Park, Streatham, S.W.*

Date of Election.	
Feb. 18, 1898.	Thelwell, F. W. Watts "*Tresillian,*" *Harlyn Bay, near Padstow, Cornwall.*
Feb. 28, 1911.	Thomas, Edwin Harvey 34, *Cleveland Park Avenue, Walthamstow, N.E.*
May 16, 1902.	Tilling, George, F.R.M.S. "*Grasmere,*" *Rydal Road, Streatham, S.W.*
Jan. 25, 1910.	Todd, Charles Stephen 25, *Hanover Road, Tottenham, N.*
Feb. 22, 1910.	Tomblin, Harold "*Killarney,*" *Heath Drive, Hampstead, N.W.*
Dec. 21, 1894.	Traviss, Will. R. 42, *Winchester Avenue, Brondesbury, N.W.*
Mar. 5, 1909.	Troughton, Henry George 52, *Lincoln's Inn Fields, W.C.*
May 24, 1910.	Troughton, Henry James "*Fellbrigg,*" 6, *Essex Road, Enfield.*
Nov. 21, 1902.	Tryon, B. F. T. *Down Hall, Epsom, Surrey.*
May 15, 1903.	Tupman, G. Lyon, Lt.-Col., F.R.M.S. *College Road, Harrow.*
June 17, 1892.	Turner, C. 20, *Minster Road, Cricklewood, N.W.*
June 21, 1901.	Tyrell, E. G. Harcourt *c/o District Native Commissioner,* 47, *St. Andrews Street, Durban, Natal, S.A.*
Mar. 16, 1906.	Vogeler, Gustav 17, *Philpot Lane, E.C.*
July 25, 1873.	Walker, J. S. 6, *Warwick Road, Upper Clapton, N.E.*
Jan. 16, 1903.	Walker, Wallace O. *Belle Vue House, Carey Place, Watford, Herts.*
Nov. 20, 1903.	Waller, W. T. 15, *Atney Road, Putney, S.W.*

Date of Election.	
Nov. 22, 1910.	Watts, Geo. W. 103, *Haverstock Hill, N.W.*
Feb. 17, 1905.	Webb, John Cooper, F.E.S. 218, *Upland Road, Dulwich, S.E.*
Dec. 21, 1900.	Webster, Rev. T. 13, *Victoria Road, Exmouth, Devon.*
June 16, 1899.	Wedeles, James, F.R.M.S. 231, *Flinders Lane, Melbourne, Australia.*
April 20, 1906.	Weeks, John 8, *Homefield Road, Bromley, Kent.*
Mar. 20, 1908.	West, Joshua Cobbett 20, *Millbrook Road, Brixton, S.W.*
Feb. 25, 1876.	Wheeler, George 64, *Canonbury Park South, N.*
Jan. 25, 1910.	Whitehead, Henry, B.Sc. Lond. *Wadham House, Toynbee Hall, Commercial Road, E.*
Dec. 4, 1908.	Wilkins, Thomas Smith *Eversley, Uttoxeter.*
Nov. 23, 1877.	Williams, G. S. *Tor Hill, Kingskerswell, Devon.*
Jan. 19, 1906.	Wilson, Joseph, F.R.M.S. *Hillside, Avon Road, Upper Walthamstow, Essex.*
May 17, 1901.	Winter, William F. G. 36, *Grove Lane, Kingston-on-Thames.*
Dec. 20, 1895.	Wood, Walter J., F.R.M.S. "*Ernecroft,*" *Abbey Road, Grimsby.*
Nov. 16, 1894.	Wooderson, Edwin "*Königsfeld,*" 39, *Dartmouth Road, Brondesbury, N.W.*
Mar. 15, 1907.	Worssam, Cecil *Hillside, St. Albans.*
April 20, 1906.	Worthington, Francis Samuel, L.R.C.P., M.R.C.S. *The Beeches, Stowmarket.*
Jan. 18, 1907.	Wright, Joseph Pepper 37, *Ravenswood Road, Redland, Bristol.*

Date of Election.

Feb. 21, 1902. Wyatt, Edward
Gordonia, Gloucester Road, Norbiton, Kingston.

Jan. 18, 1901. Wykes, William
7, *Plaistow Park Road, Plaistow, Essex.*

Nov. 23, 1888. Young, G. W., F.G.S.
34, *Glenthorne Road, Hammersmith, W.*

Nov. 15, 1907. Zehetmayr, Walter E.
Belle Vue, St. Margaret's, Twickenham.

Dec. 19, 1902. Zimmerman, Prof. C., F.R.M.S.
Antonio Viera Collegio, Rua do Sodré 43, *Bahia, Brazil.*

NOTICE.

Members are requested to give early information to the Treasurer of any change of residence, so as to prevent miscarriage of Journals and Circulars.

List of Exchanges and of Societies, etc., which Receive the Journal.

An die Redaktion des "Mikrokosmos," Pfizerstrasse, 5, Stuttgart, Germany.
American Microscopical Society, T. W. Galloway, Secretary, Decatur, Ill., U.S.A.

Bath Ladies' Microscopical Society, Miss B. Bryant, 15, Darlington Place, Bath.
Bausch & Lomb Optical Company, Publication Department, Rochester, N.Y., U.S.A.
Bergens Museums Bibliothek, Bergen, Norway.
Birkbeck College, Bream's Buildings, Chancery Lane, W.C.
Birmingham Natural History and Philosophical Society, Norwich Union Chambers, Congreve Street, Birmingham.
"Botanical Gazette," University of Chicago Press, Chicago, Ill., U.S.A.
Botanical Society of Edinburgh (The Curator), The Botanic Gardens, Edinburgh.
Botanisches Centralblatt, c/o E. F. Brill, Leyden, Holland.
Brighton and Hove Natural History Society, c/o The Public Library, Brighton.
Bristol Naturalists' Society (The Librarian), 5, Lansdown Place, Clifton, Bristol.
British Association for the Advancement of Science, Burlington House, London, W.

Canadian Institute, W. H. Vandersmitten, Esq., Secretary, 46, Richmond Street East, Toronto, Canada.
Concilium Bibliographicum, Zürich-Neumünster, Switzerland.

Croydon Natural History and Scientific Society (The Secretary), Public Hall, Croydon.

Deutsche Mikrologische Gesellschaft, München, Germany.
Dohrn, Prof. Reinhart, The Zoological Station, Naples.

"English Mechanic," 5, Effingham House, Arundel Street, W.C.
Entomological Society, 11, Chandos Street, Cavendish Square, W.
Essex Field Club, Essex Museum of Natural History, Stratford, Essex.

Geologists' Association (The Librarian), University College, Gower Street, W.C.

Herts Natural History Society, c/o Daniel Hill, Esq., "Herga," Watford, Herts.
Historical and Scientific Society of Manitoba, Winnipeg, Canada.
Horniman Museum, Forest Hill, S.E. (The Curator).
Hull Scientific and Field Naturalists' Club, Royal Institution, Hull.

Illinois State Laboratory of Natural History (Library), Urbana, Ill., U.S.A.
Imperial Leopold-Caroline Academy, Halle-an-der-Saale, Germany.

"Knowledge," The Knowledge Publishing Co., Ltd., 42, Bloomsbury Square, W.C.

Leicester Literary and Philosophical Society (The Secretary), Corporation Museum, Leicester.
Library, Bureau of Science, Manila, Philippines.
Linnean Society, Burlington House, Piccadilly, W.
Literary and Philosophical Society of Manchester (The Librarian), 36, George Street, Manchester.
Lloyd Library, Cincinnati, Ohio, U.S.A.
London Institution (The Librarian), Finsbury Circus, E.C.

Manchester Microscopical Society, J. E. Storey, Esq., 26, Grosvenor Road, Whalley Range, Manchester.
Microscopical Society of Liverpool, Royal Institution, Colquitt Street, Liverpool.
Missouri Botanical Garden, St. Louis, Mo., U.S.A.

Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne (The Librarian), Hancock Museum, Barras Bridge, Newcastle-upon-Tyne.
Natural History Museum (The Librarian), South Kensington, W.
Natural History Society of Glasgow (The Librarian), 207, Bath Street, Glasgow.
"Nature" (The Editor), St. Martin's Street, W.C.
Netherlands Zoological Society, Zoological Station, Helder, Holland.
"Nuova Notarisia," c/o Prof. G. B. De Toni, Université Royale de Modena, Modena, Italy.
"Nyt Magazin for Naturaidenskaberne," c/o Prof. Dr. N. Wille, Botan. Garten, Christiania.

Oberhessische Gesellschaft für Natur- und Heilkunde, Giessen, Germany.
Optical Society (The Hon. Librarian), 20, Hanover Square, W.

Patent Office Library, 25, Southampton Buildings, Chancery Lane, W.C.
Philadelphia Academy of Natural Sciences, Philadelphia, Pa., U.S.A.
Philippine Exposition Board, Calle General Solano 384, Manila, Philippine Islands.

R. Scuola Superiore di Agricoltura, Portici, Italy.
Royal Dublin Society, Leinster House, Dublin.
Royal Institute of Cornwall, Truro.
Royal Institution, 21, Albemarle Street, W.
Royal Society of Medicine, 15, Cavendish Square, W.
Royal Microscopical Society, 20, Hanover Square, W.
Royal Society, Burlington House, Piccadilly, W.
Royal Society of New South Wales, Sydney.

Saunders, Sibert, Esq., 197, Amesbury Avenue, Streatham Hill, S.W.
Smithsonian Institution, Washington, D.C.
Société Belge de Microscopie, c/o Mons. A. Castaigne, 28, Rue de Berlaimont, Bruxelles.
Société Botanique Italienne, Florence, Italy.
Society of Arts, John Street, Adelphi, W.C.

Tempère, Mons. J., Grèz-sur-Loing, par Bourron, Seine et Marne.

University of California Library (Exchange Department), c/o W. Wesley & Son, 28, Essex Street, Strand, London, W.C.

Victoria, Field Naturalists' Club of, A. D. Hardy. Hon. Secretary,

Wagner Free Institute, Montgomery Avenue and 17th Street, Philadelphia, U.S.A.
Wesenberg-Lund, Dr., Slotsgade, Hillerod, Denmark.
Wisconsin Academy of Sciences, Arts, and Letters (Exchange Secretary), Madison, Wis., U.S.A.

Zacharias, Dr. Otto, Biologische Station, Plön, Holstein, Germany.
Zoologisch-botanische Gesellschaft in Wien, III. 3, Mechelgasse Nr. 2, Wien, Austria.